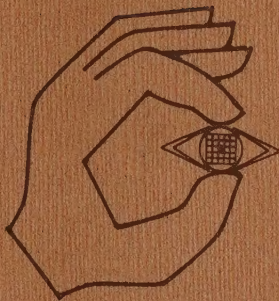


683



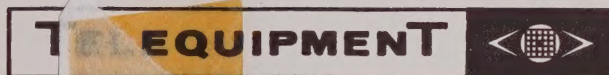
TELEQUIPMENT
OSCILLOSCOPE
TYPE D68

MP MASTER



MA24048

MANUAL



OSCILLOSCOPE TYPE D68

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Telequipment
313, Chase Road,
Southgate,
London,
N14 6JJ,
England.

TEKTRONIX, INC.,
P.O. Box 500,
Beaverton,
Oregon (97005).

Telephone: 01-882 1166

Telephone: (503) 644-0161

Telex: 262004

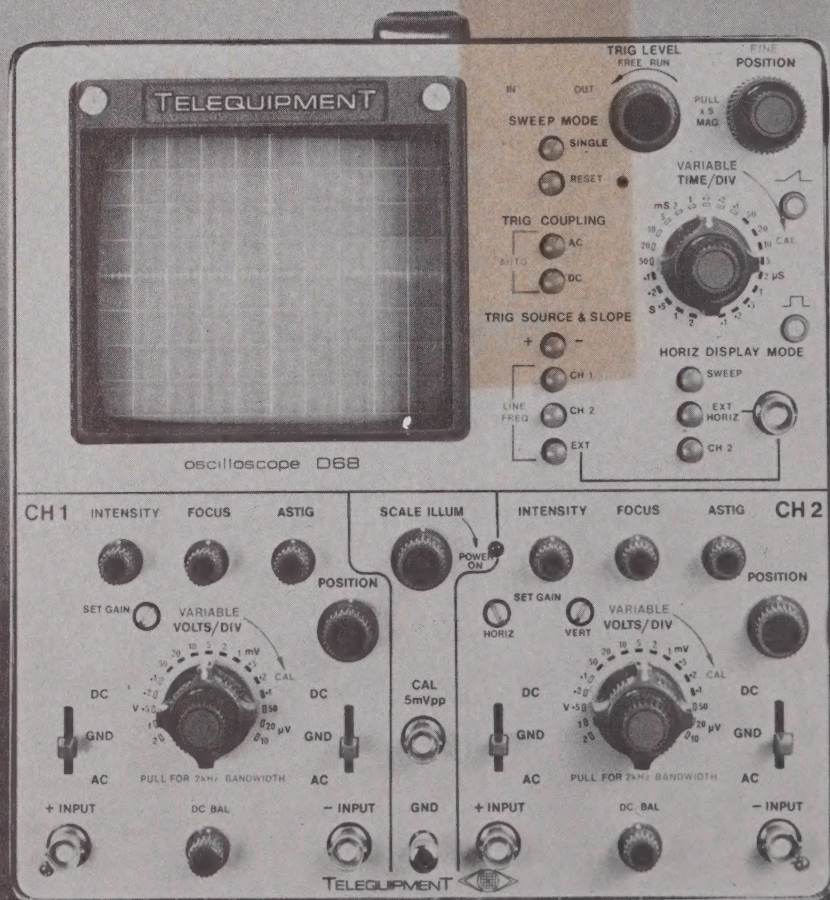
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INTRODUCTION

The D68 is a double beam oscilloscope providing bright and clear displays with a double gun CRT. Two high sensitivity differential vertical amplifiers provide up to 100,000:1 common mode rejection ratio and maximum bandwidth of 2 MHz. One amplifier may be switched to the horizontal plates to give a single beam X-Y display with high sensitivity in both directions; alternatively a double beam display can be used using an external horizontal input. The equipment incorporates field effect transistors in the input circuitry thereby reducing drift to a minimum and a solid state design to ensure fast stabilization time.

The design of this instrument is subject to continuous development and improvement, consequently this instrument may incorporate minor changes in detail from the information contained herewith.

NOTICE TO OWNER

To obviate the risk of damage during transit and facilitate packaging. The owner is requested to remove the power supply plug and NOT send the following items unless they are suspect, should this Instrument be returned to TELEQUIPMENT for servicing:—

- Manual
- Probes
- Power Supply Lead
- BNC Plugs

CONTENTS

CHAPTER		Page	CHAPTER		Page
1	SPECIFICATION		4	MAINTENANCE & CALIBRATION (contd.)	
	Cathode Ray Tube (CRT)	1/3		Horizontal Amplifier	4/4
	Dimensions	1/3		Preliminary Procedure	4/1
	Horizontal System	1/2		Trigger Amplifier	4/4
	Outputs, Front Panel	1/2		Time Base	4/4
	Power Requirements	1/3		Vertical Amplifier	4/2
	Temperature Limits	1/3		General	4/1
	Vertical System	1/1		Mechanical	4/1
	Weight	1/3		Time/Div Switch Connexions	4/6
				Volts/Div Switch Connexions	4/7
2	OPERATING INSTRUCTIONS		5	COMPONENTS LIST	
	Controls and Connectors	2/1		Assembly	5/18
	Operation	2/2		Electrical	5/2
	Pre-operational Checks	2/2		Mechanical	5/17
3	CIRCUIT DESCRIPTIONS		6	CIRCUIT DIAGRAMS	Figure
	Block Diagram	3/1		Block Diagram	1
	Calibrator & Voltage Stabilizers	3/4		Calibrator & Voltage Stabiliser	10
	CRT	3/3		CRT Circuit	9
	Horizontal Amplifier	3/3		Channel 1 Amplifier	2
	Power Supply	3/4		Channel 2 Amplifier	3
	Timebase and Bright Up	3/2		Component reference	
	Time/Div Switch	3/3		PC77	14
	Trigger Amplifier	3/2		PC87	13
	Vertical Amplifier Channel 1	3/1		PC90	12
	Channel 2	3/2		PC91	14
	Volts/Div Switch	3/2		PC92	12
				PC102	13
				PC106	13
4	MAINTENANCE & CALIBRATION			Horizontal Amplifier	8
	Calibration	4/1		Power Supply	11
	Calibrator	4/2		Timebase & Bright Up	6
	CH2 Horiz Display Mode	4/5		Time/Div Switch	7
	CRT	4/2		Trigger Amplifier	5
	Cross Talk Adjustment	4/5		Volts/Div Switch	4

CHAPTER 1

SPECIFICATION

1.1 VERTICAL SYSTEM (Both Channels)

1.1.1 Deflection Sensitivity

Calibrated (17 ranges 1-2-5 steps)
Uncalibrated (with variable)

10 $\mu\text{V}/\text{div}$ — 2 $\text{V}/\text{div} \pm 5\%$

Provides complete coverage between steps; lowest sensitivity reduced to 5 V/div approximately.

1.1.2 Bandwidth and Risetime

Sensitivity

10 $\mu\text{V}/\text{div}$
20 $\mu\text{V}/\text{div}$
50 $\mu\text{V}/\text{div}$
0.1 mV/div
0.2 mV/div
0.5 mV/div — 2 V/div

— 3 dB Bandwidth Min.

D.C. or 2 Hz to

150 kHz
300 kHz
500 kHz
1.0 MHz
1.5 MHz
2.0 MHz

Risetime Max.

(10% — 90%)

2.3 μs
1.2 μs
700 ns
350 ns
230 ns
170 ns

A switched low-pass filter reduces the — 3 dB h.f. point on all ranges to approximately 2 kHz.

1.1.3 Common-Mode Rejection Ratio (Minimum)

RANGE	FREQUENCY						
	DC to 1 Hz	10 Hz	50 to 60 Hz	100 Hz	1 kHz	10 kHz	100 kHz
10 $\mu\text{V}/\text{div}$ to 0.1 mV/div D.C. A.C.	100,000	100,000 100	100,000 500	100,000 1,000	100,000 5,000	100,000 15,000	50,000 15,000
0.2 V/div and 0.5 mV/div D.C. A.C.	50,000	50,000 100	50,000 500	50,000 1,000	50,000 5,000	50,000 10,000	25,000 10,000
1 V/div and 2 mV/div D.C. A.C.	25,000	25,000 100	25,000 500	25,000 1,000	25,000 5,000	25,000 10,000	10,000 5,000
5 mV/div to 2 V/div D.C. A.C.	1,000	1,000 100	1,000 250	1,000 500	1,000 1,000	500 500	500 500

1.1.4 Common-Mode Input Voltage Limits

V/div
10 μ to 2 m
5 m to 20 m
50 m to 2

Peak V
5
50
400

1.1.5 Input

Impedance

Standard

Alternative (links removed)

$1\text{ M}\Omega \pm 1\%$ in parallel with 47 pF max.

$10\text{ M}\Omega$ approx. in parallel with 47 pF max.

1.1.6 Noise

Source

Tangentially measured

— with 2 kHz bandwidth

$\leq 50\ \Omega$

The greater of $6\ \mu\text{V}$ or 0.05 div.

$3\ \mu\text{V}$ or 0.02 div.

1.1.7 Phase Error

1° max. up to 100 kHz

1.2 HORIZONTAL SYSTEM

1.2.1 Sweep Generator

Sweep rate

Calibrated (21 ranges 1-2-5 steps)

Uncalibrated (with variable)

$0.5\ \mu\text{s}/\text{div} - 2\ \text{s}/\text{div} \pm 5\%$

Provides complete coverage between steps;

the slowest speed reduced to approximately 5 s/div.

1.2.2 Triggering

Amplitude (min)

Internal source

External source

Ext input impedance

Frequency

DC

AC

Slope

Level

Auto

Free-run

0.5 div

100 mV

$100\ \text{k}\Omega$ in parallel with 10 pF max.

Up to 2 MHz

40 Hz to 2 MHz

+ or —

At any point on vertical waveform displayed

Level inoperative and triggering automatic

Provides sweep independent of trigger signals

1.2.3 Horizontal Amplifier

Magnifier

Ext Horiz

3 dB bandwidth

Risetime

Input impedance

Input limit

$\times 5$

DC — 2 MHz min.

175 ns max.

$100\ \text{k}\Omega$ in parallel with 10 pF max.

200 V peak

1.3 FRONT PANEL OUTPUTS

1.3.1 Calibrator

Amplitude

$5\ \text{mV} \pm 1\%$ peak to peak squarewave at supply-line frequency

1.3.2 Sweep Sawtooth

Amplitude
Source impedance

1 V peak
2.2 k Ω

1.3.3 Gate Output

Amplitude
Source impedance

1 V
100 Ω

1.4 CATHODE RAY TUBE

Type
Display area
Available phosphors
 Standard
 Alternatives
Overall accelerating potential
Z Modulation
 Coupling
 Amplitude peak to peak
 Time constant

M.O.V. 1400 D series double gun with helical PDA
7 cm x 10 cm each channel with 6 cm overlap

P31
P7, P11
5 kV

A.C. to grid of both guns
5 V for perceptible modulation
10 ms approx.

1.5 POWER REQUIREMENTS

Voltage

Power consumption
Frequency

100 – 125 V in 5 V steps
200 – 250 V in 10 V steps
45 VA
48 – 400 Hz

1.6 DIMENSIONS

Height
Width
Depth

265 mm
240 mm
520 mm

1.7 WEIGHT

14.3 kg

1.8 TEMPERATURE LIMITS, ambient

Operating
Non-Operating

–15°C to + 40°C approx.
–25°C to + 70°C approx.



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CHAPTER 2

OPERATING INSTRUCTIONS

2.1 FUNCTION OF CONTROLS AND CONNECTORS

2.1.1 SCREEN DISPLAY

SCALE ILLUM	clockwise rotation switches the power on; further rotation increases the graticule illumination.
INTENSITY	controls the brightness of the display.
FOCUS AND ASTIG	control the definition of the display.
TRACE ROTATION	aligns the axes of the CRT with the graticule.
Z MOD socket	is A.C. coupled to the CRT grid. The positive excursion of the applied signal increases the trace brightness and the negative excursion decreases it.

2.1.2 DISPLAY MODES

SWEEP	connects the sweep generator to the horizontal amplifier so that the two inputs are displayed on a horizontal time base.
EXT HORIZ	connects the signal applied to the EXT socket to the horizontal amplifier, providing a double beam X-Y display. Each vertical input is displayed as a function of the external horizontal input. The horizontal POSITION and x5 controls are effective, but sweep and trigger controls are inoperative.
CH2	provides a single beam X-Y display. The spot is deflected vertically by the CH1 amplifier and horizontally by the CH2 amplifier thus enabling CH1 signal to be displayed as a function of the CH2 signal. Only the CH1 INTENSITY, FOCUS and ASTIG controls are effective; trigger and sweep controls are inoperative.

2.1.3 DEFLECTION AMPLIFIERS CH1 and CH2

CH1 POSITION	allows the display to be moved vertically in all the three HORIZ DISPLAY MODES.
CH2 POSITION	allows the display to be moved vertically in the SWEEP and EXT HORIZ modes and horizontally in CH2 mode.
VOLTS/DIV	provides 17 calibrated deflection factors, when the VARIABLE is in the CAL position, by selecting a combination of input attenuator and amplifier gain.

VARIABLE

provides deflection factors between the calibrated VOLTS/DIV switch positions by varying the amplifier gain. The VARIABLE knob may be pulled out to limit amplifier bandwidth to about 2 kHz; this reduces the amplifier noise which may be troublesome at low deflection factors.

SET GAIN

CH1 and CH2 VERT allow the vertical gain of the amplifiers to be adjusted to maintain the specified accuracy of measurement.

CH2 HORIZ allows the horizontal gain of CH2 amplifier to be adjusted to maintain the specified accuracy of measurement. This control is effective in the CH2 display mode only.

DC BAL

correct setting in the absence of signal stops displacement of the display occurring with the rotation of the VOLTS/DIV switch.

To set DC BAL correctly, set DC-GND-AC switches to GND and VOLTS/DIV to 2 mV. Turn POSITION control to centre the display. Set VOLTS/DIV to 10 μ V and turn DC BAL to re-centre the display. Repeat if necessary.

+ and - INPUT sockets

a positive signal applied to the + INPUT deflects the spot upwards whereas the same signal at the - INPUT produces a downward deflection.

When the signal for examination is single ended, the appropriate DC-GND-AC switch is used for coupling the signal to the amplifier and the other DC-GND-AC switch is set to GND. In the case of a differential signal, both INPUT sockets are in use so the desired coupling is selected by setting both the DC-GND-AC switches to either DC or AC.

Note: Removal of LINKS two on each amplifier, increases the input impedance to 10 M Ω . These links should be removed only when using 10 μ V to 2 mV positions of the VOLTS/DIV switch as, on other switch position, removal of the links degrades the calibration accuracy without appreciably increasing the input impedance.

DC-GND-AC

DC — the signal is directly connected to the amplifier input.

AC — 100 nF D.C. blocking capacitor is interposed in the signal path.

GND — the signal is disconnected from the amplifier and the amplifier input is grounded.

2.1.4 HORIZONTAL AMPLIFIER

POSITION & FINE allow the display to be moved horizontally in the SWEEP and EXT HORIZ modes only.

x5 pulling FINE expands the display horizontally 5 times, in the SWEEP and EXT HORIZ modes only.

2.1.5 SWEEP

TIME/DIV provides 21 calibrated sweep speeds when the VARIABLE is in the CAL position.

VARIABLE provides sweep speeds between the calibrated TIME/DIV switch positions.

MODE REP (OUT) allows a sweep to be generated every time a trigger signal is received (Trigger signals received during the sweep and for a short time after are ineffective). SINGLE (IN) allows the sweep to be triggered, once only, by the first trigger signal to be received after the RESET button has been depressed. The RESET lamp indicates that the sweep is ready to be triggered.

 socket

provides a positive-going sawtooth coincident with the sweep.

 socket

provides a rectangular positive pulse coincident with the sweep.

2.1.6 TRIGGER

SLOPE + (OUT) allows the sweep to be triggered at a selected point, determined by the LEVEL control, on the positive-going part of the display or external trigger signal. — (IN) allows the sweep to be triggered at a selected point, determined by the LEVEL control, on the negative-going part of the display or external trigger signal.

SOURCE CH1 and CH2, (IN) allow the sweep to be triggered internally by one of the displayed signals. EXT (IN) allows the sweep to be triggered by a signal applied to the EXT socket. LINE FREQ (OUT) triggers the sweep internally at supply-line frequency.

EXT socket allows an external trigger signal to be connected.

COUPLING AC (IN) couples the selected SOURCE to the trigger amplifier through D.C. blocking capacitors. DC (IN) couples the selected SOURCE directly to the trigger amplifier.

LEVEL

AUTO (OUT) couples the selected SOURCE to the trigger amplifier through D.C. blocking capacitors. TRIG LEVEL is inoperative and the sweep is triggered by any suitable trigger signal without further adjustment. When trigger signals are absent, the sweep is triggered at about 30 Hz.

in conjunction with the SLOPE button, allows the sweep to be triggered at almost any point on the trigger waveform. It is inoperative on AUTO. FREE RUN is selected by operating the switch at the anticlockwise limit of the level control. The sweep runs at the maximum possible repetition rate, providing an unsynchronised display.

2.1.7 CAL socket

provides a supply-frequency square-wave of 5 mV $\pm$ 1% peak-to-peak for setting CH1 and CH2 amplifier gains.

2.2 PRE-OPERATION CHECKS

Preliminary Check

Before connecting the instrument to the supply, set the voltage selector panel corresponding to the voltage of mains supply or to the voltage nearest to it. Further, check the fuse rating: to be 500 mA for 100 — 125 V operation or 250 mA for 200 — 250 V.

The 3-core supply cable is alternatively colour coded as follows:

LINE	NEUTRAL	EARTH (GROUND)
Brown Black	Blue White	Green/Yellow Green

2.3 OPERATION

1. Connect the instrument to the mains supply and switch on with the SCALE ILLUM control. Ensure that the POWER ON lamp comes on. Allow about a minute for the instrument to warm up.

2. Set the following:

CRT Controls (CH1 and CH2)	
FOCUS	Central
ASTIG	Central
INTENSITY	Fully anticlockwise
TRACE ROTATION (Rear)	As set
Vertical Controls (CH1 and CH2)	
VOLTS/DIV	2 mV
VARIABLE	Fully clockwise and depressed
DC BAL	Central
SET GAIN	As set
POSITION	Central
DC-GND-AC	GND

Triggering controls

SOURCE	CH1
SLOPE	+
COUPLING	AUTO
LEVEL	FREE RUN (Fully anticlockwise)
SWEEP MODE	REP

Horizontal Controls

TIME/DIV	5 ms
VARIABLE	Fully clockwise
POSITION	Central
FINE	Central and x1 (Depressed)
DISPLAY MODE	SWEEP

3. Rotate CH1 INTENSITY control until a trace appears, adjust FOCUS and ASTIG for the best definition and TRACE ROTATION, if necessary, to make the trace horizontal.

Note: Vertical movement of the trace may occur when VOLTS/DIV is operated. The trace movement may be eliminated by first adjusting POSITION on 2 mV setting and then DC BAL on 10 μ V, centering the trace in each case.

4. Proceed as in 3 above to obtain CH2 trace, adjusting CRT controls for CH2.
5. Apply the 5 mVp-p CAL signal to the + INPUT of both channels. Set the appropriate DC-GND-AC switches to DC and note the unsynchronised display for both channels.
6. Turn the LEVEL control clockwise and note that the two displays are synchronised. Alternatively, synchronisation of the display may be achieved by depressing AC or DC button of the TRIG COUPLING and then turning the LEVEL clockwise to obtain the displays.

Note: When AC has been selected, the starting point of the display moves as the POSITION is turned whereas in case of DC TRIG COUPLING, the starting point does not move with POSITION.

7. Select CH2 HORIZ DISPLAY MODE; note that CH1 controls the vertical deflection of the resulting single beam display, and CH2 the horizontal deflection.

Note: Only CH1 CRT controls are effective.

CHAPTER 3

CIRCUIT DESCRIPTIONS

3.1 BLOCK DIAGRAM — Figure 1

The main purpose of the block diagram is to show how the trigger and horizontal deflection signals are routed by the TRIG SOURCE and HORIZ DISPLAY MODE switches. Vertical deflection and unblanking signal paths are also shown, but no attempt has been made to show the function of all front-panel controls and switches.

3.2 VERTICAL AMPLIFIER CH1 — Figure 2

3.2.1 In the DC position of the + input switch, the signal applied to the + input socket is connected to the gate of TR751A through S751, the input attenuator (Para 3.4.1) and the network comprising R767, R772 and C757, and R758 suppress oscillation in the input stage. C753 is a D.C. blocking capacitor which is brought into circuit in the AC position of S751. D756 and D758 protect TR751A if a high voltage is connected to the input. R767 and R772 limit the current in these diodes and C757 prevents high-frequency attenuation in R767 and R772. D761 and D762 provide reverse bias for D756 and D758, and also supply current to R773. This allows the gate current of TR751A and the reverse currents of D756 and D758 to be compensated.

The — input socket is connected to the gate of TR751B through similar coupling, attenuation, suppression and protection components. The network comprising R767, R772 and C757, and the corresponding network in the — input attenuate the input signals slightly. Adjustment of R767 and C761 allows this attenuation to be equalized; preserving the high common-mode rejection of the amplifier.

3.2.2 The input resistance of the amplifier is normally $1\text{ M}\Omega$. It may be increased to $10\text{ M}\Omega$ on ranges $10\text{ }\mu\text{V}/\text{div}$ to $2\text{ mV}/\text{div}$ by removal of the links in series with R761 and R762.

3.2.3 TR753 — TR756 and associated components minimize the adverse effects of differences between TR751A & B on common-mode rejection.

TR755 supplies constant current to the sources of TR751A and B, thus minimizing the effects of the difference in transconductance of TR751A & B. The effect of the difference in output conductance is minimized by the action of TR753 and TR754. The common-mode signal at the sources of TR751 is reproduced at the bases of TR757 and TR758 without change of amplitude but at a higher D.C. potential. Since the emitters of TR757 and TR758 are connected to the drains of TR751, there is no change in drain-to-source voltage in response to the common-mode signal and the difference in output conductance is prevented from producing a common-mode output. TR756 supplies constant current to the coarse D.C. balance R793, so that common-mode rejection is not degraded. R789 provides a small adjustment for low-frequency common-mode response; C766 and C771 have similar function at high frequency. D763 and D764

compensate for temperature variation in the emitter base voltage of the constant current transistors with which each is associated.

3.2.4 The differential component of the signal applied to the gates of TR751 appear after amplification at the collectors of TR757 and TR758. Resistors selected by the volts/div switch are connected between the collectors of the transistors, varying the gain of the input stage from 300 to 1.5. R793 equalizes the D.C. currents in R794 and R795 so that the quiescent trace position is independent of the volts/div switch setting. R796 is the fine balance control, operated from the front panel.

The signals applied to one gate of TR751 are coupled to the other gate by stray capacity inside TR751. The purpose of R777, R778, C763 and C764 is to neutralize these unwanted signals. The +62 volts and -11 volts supplies to the input stage are stabilized in order to minimize D.C. drift.

3.2.5 R802 is the front panel variable volts/div control providing 2.5:1 variation in amplifier gain. Thermistor TH651 compensates for the changes in transconductance with temperature of the two pairs of field effect transistors viz; TR751, A & B and TR761, A & B. R805 is adjusted to ensure no vertical trace shift when R802 is varied. S753, closed by pulling the variable knob, connects C773 and R808 between the drains of TR761, A & B. This reduces the displayed noise by limiting the amplifier bandwidth to 2 kHz. R814 is a front panel position control and R815 centres the range of control. TR763 provides the voltage for R814 and R815.

3.2.6 TR762 completes the D.C. feedback loop between the emitters of transresistance stage TR764 — TR765 and drains of transconductance TR761, A & B. This feedback loop makes the potential at TR764 and TR765 emitters dependent on the -12 V line and not on the D.C. conditions of TR761A & B. The variation of emitter potential in conjunction with D776 makes the gain of TR761 A & B directly proportional to the supply-line voltage, compensating for the effects of supply-line voltage on the vertical sensitivity of the CRT. The D.C. feedback loop also ensures equal changes in the drain currents in spite of asymmetric injection of current by R814 and R815. The preset R811 compensates for the inequality in the transconductance of the two field effect transistors TR761A & B minimizing trace movement with change of supply-line voltage. C775 and R823 provide high frequency compensation.

3.2.7 TR768, TR769, TR771 and TR772 constitute a differential cascode amplifier, the output of which is applied to the vertical deflector plates of the CRT. R844 in the emitter circuit is the front panel set gain control. A balanced trigger signal is derived from the emitter circuit to initiate the time base (Fig. 6) via the trigger amplifier (Fig. 5). R853 sets the D.C. component of the trigger output; C781 and C782 provide high frequency compensation.

3.3 VERTICAL AMPLIFIER CH2 – Figure 3

3.3.1 CH2 differs from CH1 only by the inclusion of TR616, TR617 and associated components. This circuit is described in the following paragraph, but for the remainder of the CH2 amplifier, reference should be made to the CH1 circuit description paragraphs 3.2.1 to 3.2.7.

3.3.2 In the CH2 horizontal display mode, the output of TR616 and TR617 is connected by S4C to the horizontal amplifier (Fig. 8); in the other two display modes, D617 and D618 conduct and the signal is effectively short-circuited. R683 is the front-panel CH2 HORIZ SET GAIN control. R688 sets the mean potential of the horizontal plates, R687 balances the horizontal amplifier and C628 provides high-frequency compensation, all in the CH2 horizontal display mode only.

3.4 VOLTS/DIV SWITCH – Figure 4

3.4.1 Three frequency compensated resistive dividers, with ratios 1000:1, 100:1 and 10:1 are used for each input. These attenuate the input signal applied to the socket(s) and pass it to the vertical amplifiers CH1 or CH2 (Fig 2 & 3).

3.4.2 The resistive dividers are similar apart from the inclusion of presets R903, R905 and R908 in the + input divider sections; these presets enable the attenuation of both the inputs to be equalized for the best common mode rejection ratio. Trimmers C901, C903, C906, C909, C913, C916 and C919 are adjusted to make the input capacitance the same on all switch positions; C902, C905, C908, C912, and C918 are adjusted to make the attenuation of each attenuator section independent of frequency.

3.4.3 When VOLTS/DIV positions from 2 V to 5 mV are selected, the signal applied to each socket is attenuated by one of the capacity compensated dividers. On positions 2 mV to 10 μ V, the signal is passed to the amplifier without attenuation.

3.4.4 Wafers 5 and 6 of the volts/div switch enable the collector load resistance of TR757-TR758, when using CH1 or TR607-TR608 for CH2 to be varied by selecting R915-R919 and R921-R922 across the collector load – this variation in the load in conjunction with the ratio of the resistive divider, provides the selected deflection sensitivity.

3.5 TRIGGER AMPLIFIER – Figure 5

3.5.1 The amplifier may be triggered internally from CH1, CH2 or the line frequency; externally from a signal applied to the EXT HORIZ socket on the front panel. These triggering signals, after being selected by a three button self-cancelling switch S3B-D, are applied to a transresistance stage, TR1 and TR2, via polarity select switch S3A and coupling switch S2A-B. In the + position of the polarity switch S3A, the level control R2 allows a trigger point to be selected anywhere on the positive-going part of the trigger signal; similarly, the – position of S3A allows a point on the negative-going part to be selected.

3.5.2 In the auto position of the coupling switch S2A-B, the Schmitt output is integrated by R26, R27 and C9 and fed back to the input stage TR2. This feedback causes the trigger amplifier to oscillate at about 30 Hz in the absence of a trigger signal. This oscillation is synchronized by a trigger signal of sufficient amplitude. Adjustment of the mark-to-space ratio to unity in the absence of a trigger signal by means of R7 ensures maximum trigger sensitivity.

3.5.3 Internal triggering signals from either vertical amplifiers are fed in balanced form to the bases of TR1 and TR2 so that the hum originating in the vertical amplifiers is cancelled. D3 and D4 protect the circuit from over voltage applied inadvertently to the EXT HORIZ socket. D1 and D2 minimize the D.C. voltage appearing at the socket.

3.5.4 TR3 and TR4 forming a Schmitt trigger circuit produce a rectangular output to initiate the time base (Fig 6). C7 is a speed-up capacitor; R22 controls the backlash. TR5 protects the Schmitt trigger from the effects of supply variation by ensuring that fluctuations in –12 V line are reproduced in the positive line.

3.6 TIME BASE AND BRIGHT UP – Figure 6

3.6.1 The circuit essentially consists of the Miller run-up stage TR43-TR44, the sweep-gating bistable TR41-TR42, the hold-off bistable TR45-TR46 and the bright-up stage TR47-TR48.

3.6.2 Initially, D41 is slightly biased off and not conducting; TR42 of the sweep-gating bistable is off and TR41 on; TR45 of the hold-off bistable is off and TR46 on; D42-D44 are conducting and the collector current of TR41 is being maintained by +85 V supply line through the emitter of TR47.

3.6.3 When a trigger pulse (Fig 5) is applied to the differentiator formed by C41 and R42, the negative-going edge turns D41 on causing TR42 of the sweep-gating bistable to conduct and TR41 to cut off. TR42 collector goes negative and the resulting negative voltage cuts off D41 and prevents any further trigger pulses from entering the circuit.

3.6.4 The negative excursion of TR42 collector also lowers the potential of the junction of D42, D43. This biases D43 and D44 off thus allowing the gate of TR43 to go negative. TR44 with TR43 forms a high gain amplifier and the timing capacitors CT (Para 3.7.1 Fig.7), effectively forming a negative feedback loop between gate of TR43 and collector of TR44, charge up at a rate determined by RT (Para 3.7.1 Fig.7). This begins the sweep. D46 conducts while the hold-off capacitors charge. At the instant, the positive-going sweep reaches a pre-determined level sufficient to switch the bistable TR45-TR46, the sweep ends. TR45 conducts; its collector voltage goes negative turning D45 on. This alters the base biasing of TR42 and the bistable TR41, TR42 once again switches over, reverting to its original state. D43 and D44 conduct once again, making the gate of TR45 more positive. The voltage at the collector of TR44 starts to fall and, as flyback continues, the current in D43 and D44 flows into the timing capacitors. Flyback ends only when TR44 collector voltage has fallen low enough for D42 to conduct. Incoming trigger pulses however will not affect the bistable

TR41, TR42 due to the large negative potential at TR42 base which prevents further switching action.

3.6.5 At the start of flyback D46 cuts off and TR45 base moves negative as the hold-off capacitors discharge through R67 and R65 until eventually the bistable TR45, TR46 resets. The collector voltage of TR45 goes positive thus turning D45 off. The original conditions (Para 3.6.2) are re-established and the next input trigger pulse will switch the sweep gating bistable and the whole cycle is repeated.

3.6.6 The sweep also available at the front panel socket  is fed to the horizontal amplifier (Fig. 8) via R63 and R64. R63 is used to preset the gain of the horizontal amplifier and C55, the high frequency compensation. R56 in the source of TR43 is adjusted to obtain 0 V at the gate of TR43 and C45, the high frequency compensation. R44 is adjusted to set TR41 base voltage to a value which is sufficient to put the gating bistable TR41, TR42 in a triggering condition, but is insufficient for self triggering. R72 and R76 in the hold-off bistable are adjusted to set the sweep length and hold-off period respectively. The timing-resistor chain is connected to the unstabilized -12 V line so that the sweep speed varies with supply line voltage. This compensates for the variation in CRT horizontal sensitivity with supply line voltage.

3.6.7 In the single position of S1A, the hold-off bistable is reset not by the discharge of the hold-off capacitor but by the operation of reset button S1B. The current in R66 prevents the base of TR45 going sufficiently negative to reset the hold-off bistable after flyback has occurred. Operation of the reset button resets the hold-off bistable by applying a positive pulse to the base of TR46. Illumination of LP1 indicates that the hold-off bistable has been reset.

3.6.8 TR47 of the bright up stage is switched off during the sweep simultaneously with sweep-gating bistable. When TR47 is off, its collector voltage rises to +85 volts. Grid g3 of the CRT through the emitter follower coupling also rises and causes the electron beam to be turned on. On ext horiz and CH2 positions, the beam is unblanked through S4B. The fast edged pulse tapped off the emitter load is also provided on the front panel for probe capacitance compensation.

3.7 TIME/DIV SWITCH — Figure 7

3.7.1 Timing capacitors C105-C108, in combination with R109 and R111-R118 are, via wafer 2F-2R, selected by time/div switch to provide 21 sweep speeds between 0.5 μ s and 2 s/div. On receipt of the trigger pulse, the time base and bright up (Para 3.6 and Fig 6) operate; capacitors charge linearly up to the end of the sweep.

3.7.2 R108, a front panel control, provides the calibrated sweep speeds when turned fully clockwise and uncalibrated sweep speed at any other position since the charging current for the capacitors is decreased. R101-R106 selected concurrently with the timing capacitors provide a constant load on R108.

3.7.3 C101-C104 provide hold-off time; during this time the timing capacitors discharge. Further occurrence of the next sweep is inhibited until the hold-off capacitors are discharged (Para 3.6.5).

3.8 HORIZONTAL AMPLIFIER — Figure 8

3.8.1 The horizontal amplifier incorporates two sections: The pre-amplifier formed by TR201-TR204 and the output amplifier formed by TR205-TR208. The desired horizontal display mode is selected by depressing A, B or C of S4 providing SWEEP, EXT HORIZ or CH2 modes respectively. In the SWEEP and EXT HORIZ modes, the signal and position currents are mixed at TR201 base whereas in CH2 mode, the pre-amplifier section is not used and the horizontal deflection signal from CH2 vertical amplifier (Figure 3) is fed directly to the output amplifier. The sweep generator is disabled in the EXT HORIZ as well as CH2 modes.

3.8.2 TR201 is a shunt feedback stage whose transconductance is determined by R207. Signal current from either the sweep generator or the EXT HORIZ socket is mixed with position current and applied to TR201 base. R205 ensures that expansion is about the centre of the CRT screen and C202 allows pulse response optimisation. TR202 ensures that the base of TR204 is fed from the same impedance as that of TR203 so that hum from the +12 V line is rejected. D208 protects TR201 from overload and D201 ensures that no D.C. voltage appears at the EXT HORIZ socket.

3.8.3 TR203 and TR204 constitute a long-tailed pair which converts the single-ended voltage signal applied to the base of TR203 into a push-pull current signal. R213 and R214 determine the transconductance of the stage in the unmagnified condition and R214 sets the current gain of the pre-amplifier. R216 sets the x5 magnification exactly, R218 centres the range of the position control and R221 sets the mean potential of the horizontal deflector plates in the SWEEP and EXT HORIZ modes.

3.8.4 In the SWEEP and EXT HORIZ modes, the collector currents of TR203 and TR204 flow through S4C and R223-R224 to the -12 V line. But in CH2 display mode, these collector currents flow to ground through D202 and D203.

3.8.5 TR205, TR206, TR207 and TR208 constitute a push-pull shunt feedback stage, R229 and R231 determining the transresistance of the stage. Inclusion of two emitter followers TR205 and TR206 enables a high value of transresistance to be attained without loss of gain-stability. C206 and C208 are twisted-wire capacitors (adjusted for optimum pulse response). The values of R223 and R225 are such that D206 cuts off when the spot is deflected off-screen to the right and TR207 is prevented from saturating. Similarly D207 protects TR208 when the spot is deflected off-screen to the left. D204 and D205 prevent large voltage excursions at the amplifier input when either D206 or D207 is cut off thus preventing the preceding stage from saturating.

3.8.6 Compensation for the slight horizontal movement of the spot occurring when the beams are turned on at the start of the sweep is also achieved by applying a small amount of bright-up signal through R230 to the horizontal amplifier.

3.9 CATHODE RAY TUBE — Figure 9

3.9.1 The common horizontal and independent vertical deflector plates are used for the two beams of the double-gun cathode ray tube. All the controls for the two beams are electrostatic, except trace rotation which is magnetic.

3.9.2 The overall acceleration potential for the two beams is 5 kV; + 4 kV on P.D.A. and - 1 kV approx. on k' and k". The inter-plate shield potential is provided by preset R304 which is adjusted for optimum geometry.

3.9.3 R308 allows the accelerating voltage on one gun to be adjusted so that the horizontal sensitivity of the two guns can be equalized. The position of the link "abc" depends on which gun requires the higher voltage. D301 and D302 help to keep the accelerating voltage independent of cathode current.

3.9.4 Z mod socket, on the rear panel, is coupled to both the grids via C304 and a positive marker pulse applied to the socket brightens the trace.

3.9.5 The unblanking of the two beams is achieved by connecting + 85 V to g3 during the sweep time via an emitter follower TR48 (Fig 6); at other times, TR48 is cut-off and g3 voltage drops to 20 V. The beam is also unblanked in EXT HORIZ position of the switch S4C or in the CH2 position of the switch S4C. The adjustment of R311 aligns the two beams horizontally.

3.9.6 R452, on the rear panel, is adjusted to compensate for the misalignment of electrical and mechanical axes. The current for the trace rotation coil L301 is provided by the resistive network formed by R451-R456; this also provides 85 V for CH1, CH2 and time base & bright-up (Fig. 2, 3 and 6).

3.9.7 R302 and R315, on the front panel individually control the focus of the two beams by applying adjustable voltages to a2' and a2" respectively. This voltage is provided by -1.1 kV line. R314 & R316 ensure correct voltage for R315; R301 and R303 ensure the same for R312. C301 and C307 minimize the transient effects.

3.9.8 R305 and R309, on the front panel, control the astigmatism by applying adjustable voltages between 0 and +105 V to a3' and a3" respectively. C302 and C307 minimize the transient effects.

3.9.9 R307 and R312, on the front panel, are intensity controls and apply adjustable voltages with respect to cathode potential to g1' and g2".

3.10 CALIBRATOR AND VOLTAGE STABILIZERS — Figure 10

3.10.1 Calibrator

During the positive excursion of the 12.9 volts A.C. supply, D1004 conducts and the voltage at its anode is between 0 and 0.7. The anode of D1003 is more positive than that of D1001 therefore D1003 conducts, D1001 cuts off and the calibrator output is zero.

During the negative excursions, D1004 and D1003 are cut off and the current determined by R1002 and R1003 flows through D1001 and R1001. This current is adjusted by means of R1003 so that exactly 5 mV is developed across R1001. The variation with temperature of the forward voltage of D1001 is compensated approximately by the temperature dependent Zener voltage of D1002.

3.10.2 +62 V Stabilizer

The base of TR502 is maintained at a constant voltage by Zener Diode D501. The +62 V stabilized line is derived from the emitter of TR502, R503 and R506 limit the power dissipation in TR502.

3.10.3 -11 V Stabilizer

The -11 V line is compared with the +62 V line in R504 and R505. Variations in the -11 V line are amplified by TR501 and fed to the base of the series transistor TR503. Thus variations in the -11 V line are minimized whether caused by change in load-current or supply-line voltage. R507 improves the stability of -11 V line.

3.11 POWER SUPPLY — Figure 11

3.11.1 The excitation for the power transformer T401 is derived from the mains supply which is fed via line fuse F401, mains switch S402 and voltage selector panel to connect the two primary windings in series for operation from 200-250 V and in parallel for 100-125 V operation.

3.11.2 The secondary voltages of T401 are distributed as follows:

- (a) 6.3 volts on load to CRT heater.
- (b) 14 volts on load to the power-on lamp LP401 and scale illumination lamps LP402-403. R401 on the front panel controls the intensity of graticule illumination.
- (c) 47.1 volts to the voltage doubler formed by D412-D413, C405 and C409 to produce +108 V D.C., 14 V D.C. in series with it increases the D.C. voltage to 122. R407 and C418 filter the supply.
- (d) 12.9-0-12.9 V to two full-wave rectifiers formed by D405-D406 and D407-D408 to produce +12 V D.C. and -12 V D.C. respectively. C412 and C413 are reservoir capacitors. R403-R406 and C414-C416 filter the supplies. 12.9 V r.m.s. is also tapped off to provide line-frequency trigger (Fig 5) and to activate the calibrator (Fig 10).
- (e) 824 volts to half wave rectifier D409 to produce -1025 V D.C., C406-C408 being reservoir capacitors.
- (f) 824 volts are also applied to the voltage quadrupler formed by D401, 402, 410, 411, and C402, 403, 410, 411 to produce +4 kV.
- (g) The other unsmoothed D.C. voltages tapped off are +122 V, and -14 V, these being applied within the instrument as required.

CHAPTER 4

MAINTENANCE AND CALIBRATION

4.1 GENERAL

4.1.1 The entire solid-state design of the instrument should render frequent re-adjustment of the internal preset controls unnecessary; however, to ensure full measurement accuracy, it is desirable to make an occasional check, reference 4.3.2 on the vertical amplifier sensitivity and timebase sweep speed. The internally generated 5 mV peak to peak calibration waveform may conveniently be used for these checks.

4.1.2 Should a more complete calibration be required, such as in the event of transistor replacement, reference should be made to the appropriate procedure in the Calibration paragraph of this Chapter. Before it is assumed that a fault condition exists, control settings should be verified with reference to the Pre-Operational checks, paragraph 2.2.

4.2 MECHANICAL

4.2.1 LOCATION OF PRESET CONTROLS

Attenuator trimmers are accessible from the under side, front after the covers have been removed. PC90 and PC91 which carry the circuits for the CH2 vertical amplifier and trigger, timebase and horizontal amplifiers respectively are situated on the right hand side; PC106, the CH1 vertical amplifier, is on the left hand side. The boards are marked with a legend to facilitate component identification.

4.2.2 ACCESS TO INTERIOR

The cabinet sides are removed as follows:

1. Disconnect the power supply.
2. Loosen the two handle-clamp securing screws.
3. Ease the top of each side outwards.
4. Unhook the bottom of each side from the locating slots. The bottom plates and rear cover are secured by screws.

4.2.3 CRT REMOVAL

1. Remove both cabinet sides, as described above.
2. Remove the rear cover (four screws).
3. Unplug the 12 pin CRT base connector.
4. Unplug the nine neck pin connectors.
5. Unplug the trace rotation coil connector (rear PC91).
6. Remove the two screws holding the mumetal screen.
7. Remove the CRT and screen from the instrument by moving these towards the rear to clear the front panel and the forward end of the CRT outwards.
8. Remove location moulding.
9. Withdraw the CRT from the screen.
10. Remove adhesive tape.

4.2.4 CRT FITTING

Reverse the order detailed above 4.2.3. If the trace rotation control does not provide an adequate range of adjustment reverse the trace rotation plug.

4.3 CALIBRATION

4.3.1 The following procedure enables a full calibration of the instrument to be accomplished. If any operations are carried out in isolation, regard should be paid to the risk of interaction with other adjustments also to control settings and waveforms applied in earlier steps.

The following equipment or equivalent are required:

1. Multimeter 20 k Ω /V.
2. Sine Wave Generator 1 kHz – 10 MHz.
3. Square Wave Generator capable of producing 1 kHz, 10 kHz and 100 kHz.
4. Time Marker Generator capable of producing 1 μ s, 100 μ s and 1000 μ s markers within 0.01% accuracy.
5. Single Beam Oscilloscope.
6. 10:1 Attenuator Probe.
7. Variac.

4.3.2 The instrument may be calibrated on one range only of the VOLTS/DIV and TIME/DIV switches without the use of test equipment.

The TIME/DIV calibration depends on the accuracy of the supply frequency. To calibrate the 1 mV and 10 ms ranges, proceed as follows:

Set both VOLTS/DIV switches to 1 mV, TIME/DIV to 10 ms and all the variables to CAL. Select SWEEP horizontal display mode. Display the 5 mVp-p CAL signal on CH1, DC-coupled. If the display amplitude lies outside the range 4.8 to 5.2 divs, adjust SET GAIN.

Note the horizontal distance occupied by three cycles of the CAL waveform.

If the supply frequency is 50 Hz, 3 cycles should occupy between 5.8 and 6.2 divs; for 60 Hz, between 4.8 and 5.2 divs. Adjust R683 (inside the instrument) if the display lies outside these limits.

Display the CAL signal on CH2, DC-coupled. If the display amplitude lies outside the range 4.8 to 5.2 divs; adjust VERT SET GAIN.

4.3.3 PRELIMINARY PROCEDURE

1. With the instrument disconnected from the power supply, remove the cabinet sides as detailed in 4.2.2.
2. Insert the voltage-selector plug in the rear panel with the arrow indicating the nominal voltage of the local A.C. supply or the nearest value to it.
3. Connect the Oscilloscope's power cable to a Variac. The cores of the cable are alternatively colour-coded as follows:

LINE	NEUTRAL	EARTH (Chassis)
Brown Black	Blue White	Green/Yellow Green

4. Set front panel controls as follows:

POSITION (CH1 & 2)	Central
OFF-ON	OFF
ALL VARIABLES	fully clockwise
STABILITY	fully clockwise
POSITION (horizontal)	Mid position
FINE	Central and pushed in
All push buttons	released

- Connect the Variac to the power supply, switch on power supply and allow oscilloscope to warm up.
- Adjust the Variac to give the same voltage as that indicated by the voltage-selector plug.
- Connect CAL to CH1 + INPUT and set controls for a convenient display. Adjust BRILLIANCE, FOCUS and ASTIG for best definition.

4.3.4 D.C. VOLTAGES WITH RESPECT TO GND

When the voltage values are different to that shown below a fault may be suspected.

Test points, detailed below, are PC No followed by pin No. Col 2 below gives figure number and grid location.

TEST POINT	LOCATION	VOLTAGE
90/3	12/D4	- 10.5 to - 11.5 V
90/4	12/E4	+ 58 to + 65 V
90/16	12/G4	+ 80 to + 90 V
91/1	14/B3	+ 11.5 to + 12.5 V
91/27	14/F4	12.4 to 13.4 V A.C.
91/30	14/F4	- 13.5 to - 14.5 V
91/36	14/G2	- 950 to - 1050 V
91/41	14/G2	+ 115 to + 130 V
91/46	14/H2	+ 11.5 to + 12.5 V
91/54	14/I3	+ 100 to + 110 V
106/3	13/G4	- 10.5 to - 11.5 V
106/4	13/G4	- 58 to + 68 V
106/16	13/D4	+ 80 to + 90 V
106/25	13/D2	- 11.5 to - 12.5 V

4.4 CATHODE RAY TUBE

4.4.1 TRACE ROTATION ADJUSTMENT

Set VOLTS/DIV, VARIABLE and DC-GND-AC of both channels to 2 mV, CAL and GND respectively. Display two traces horizontally on FREE RUN mode of the time base. Position the traces near the centre of the CRT and adjust TRACE ROTATION (Rear panel) to make the traces exactly parallel to centre horizontal graticule line. If the control has insufficient range, reverse the 2-pin plug.

4.4.2 HORIZONTAL ALIGNMENT AND SENSITIVITY EQUALIZATION. R308, R311

Display a 5 mV 1 kHz squarewave on both channels with VOLTS/DIV set to 2 mV. Adjust R311 for alignment of traces at centre of screen. Adjust R308 for alignment traces near the extremes of the screen.

(If the adjustment provided by R308 is insufficient, move the wirelink between pins a and b to bridge pins a and c or vice versa this however, is unlikely to be necessary unless the CRT has been replaced).

Readjust R311 and R308 to obtain the best compromise between alignment at centre and edges of screen.

4.4.3 GEOMETRY. R304

Depress EXT HORIZ button. Apply simultaneously two sine waves of different frequencies to CH1 and EXT HORIZ sockets and obtain 9 x 7 divs. rectangular raster. Adjust R304 to optimise the shape of raster. Transfer CH1 input to CH2 and display raster. Examine the raster shape and re-adjust R304, if necessary, for the best compromise between the rasters on CH1 and CH2. Disconnect the sine wave input.

4.5 CALIBRATOR

4.5.1 AMPLITUDE ADJUSTMENT. R1003

R1003 allows the calibrator to be exactly set with reference to an external standard. The following method is suggested:

Bias off D1003 temporarily by connecting the negative end (the end not marked with the + sign on the P.C. Board) to 91/27 (-11 V STAB supply line) and measure the calibrator output using a digital voltmeter. Adjust R1003 if necessary for a reading of exactly - 5 mV. Remove the temporary link.

4.6. VERTICAL AMPLIFIERS CH1 AND CH2

Notes:

- CH1 component references are given first, followed by those for CH2 in brackets. Attenuator component references are the same for the two channels.
- The adjustment of C628, R687, R688 and HORIZ SET GAIN are described in paragraph 4.10 and the adjustment of R853 (R703) in paragraph 4.9.9.
- All the adjustments should be performed with the VARIABLE pushed in to disconnect the 2 kHz filter.

4.6.1 D.C. ADJUSTMENT. R815 (R665)

Set VOLTS/DIV to 2 mV; turn the VARIABLE control fully clockwise. Set POSITION and DC BAL centrally, SET GAIN (VERT) fully clockwise and the two DC-GND-AC switches to GND. Adjust R781 (R631) to obtain a D.C. voltage of + 15 on the lower end of R794 (R644). Use the 100 V range of the meter to reduce the loading effects.

With the controls set as in the preceding paragraph, adjust R815 (R665) to centre the trace. Set VOLTS/DIV to 10 μ V and centre the trace as far as possible with R793 (R643) and then with DC BAL. Return VOLTS/DIV to 2 mV and re-adjust R815 (R665) to centre the trace. Set VOLTS/DIV again to 10 μ V and re-adjust DC BAL to centre the trace. The position of the trace should now be independent of the setting of the VOLTS/DIV switch. If this condition is not met at any time, adjust POSITION on 2 mV setting of VOLTS/DIV and DC BAL on 10 μ V, in that order, to centre the trace. Adjust R805 (R655) for no trace shift as VARIABLE is turned throughout its range. Return VARIABLE to clockwise limit.

4.6.2 SUPPLY VOLTAGE COMPENSATION. R811 (R661), R815 (R665)

Connect the instrument to the supply voltage through an adjustable transformer (Variac). Set the voltage to correspond to the voltage selector panel of the instrument.

Select SWEEP HORIZ DISPLAY mode. Set input switches to GND, VOLTS/DIV to 2 mV. Set TRIG LEVEL to FREE RUN. Set the trace to the centre of the screen. Adjust R811 (R661) to the position where variation of the supply voltage produces no permanent vertical movement of the trace. (Disregard the transient displacement). Adjust the POSITION control and R815 (R665) to compensate for the vertical movement produced by R811 (R661), finally adjusting R815 (R665) to make the range of the POSITION control symmetrical.

4.6.3 GATE CURRENT COMPENSATION. R773 (R623), R774 (R624)

Connect + and - INPUTS externally to chassis. Set VOLTS/DIV to 0.1 mV and DC-GND-AC switches to GND. Note the trace position. Set the + INPUT DC-GND-AC switch to AC. Adjust R773 (R623) to restore the trace position. Return DC-GND-AC to GND. Similarly, adjust R774 (R624) for no trace shift when the - INPUT is switched from GND to AC. Reset DC-GND-AC to GND.

When R773 (R623) and R774 (R624) have been adjusted correctly, no trace movement should be noticeable when DC-GND-AC switches are operated. Remove the wires connecting the two input sockets to the chassis.

4.6.4 GAIN ADJUSTMENT

Set VOLTS/DIV to 1 mV and VARIABLE to CAL. Display 5 mVp-p CAL signal. Adjust SET GAIN (VERT SET GAIN) for the displayed amplitude to be exactly 5 divs.

4.6.5 PULSE RESPONSE OPTIMISATION. C775 (C625)

Apply 100 kHz square wave from the generator to + INPUT via a correctly terminated co-axial cable. Set VOLTS/DIV to 0.5 mV and VARIABLE to CAL. Obtain a display and adjust C775 (C625) for a response having the fastest possible rise-time consistent with satisfactory pulse shape.

4.6.6 D.C. CMRR ADJUSTMENT. C789 (R639)

Set DC-GND-AC switches to DC, VOLTS/DIV to 2 mV and VARIABLE to CAL. Note position of trace. Apply simultaneously 5 V D.C. to both INPUTS. Adjust R789 (R639) for minimum displacement from position noted above; this may occur with R789 (R639) at its anticlockwise limit (R639 at its clockwise limit).

4.6.7 ATTENUATOR D.C. ADJUSTMENT. R903, R905, R908

With DC-GND-AC switches to DC and VOLTS/DIV and VARIABLE set to 5 mV and CAL respectively, apply simultaneously 25 V D.C. to both the INPUTS. Adjust R908 to restore the trace position and check that no displacement occurs when the input signal is removed and then re-connected. Similarly, adjust R905 on 50 mV setting. Increase the input to 100 V, set VOLTS/DIV to 0.5 V and adjust R903 for no displacement.

4.6.8 INPUT NEUTRALISATION. C763 (C613), C764 (C614)

Set VOLTS/DIV to 2 mV and VARIABLE to CAL. Apply 1 kHz square wave to + INPUT. Examine the display with

- INPUT switch at GND. Set - INPUT switch to DC and adjust C763 (C613) for identical display. Transfer 1 kHz square wave to - INPUT and examine the display with + INPUT switch at GND. Set + INPUT switch to DC and adjust C764 (C614) for identical display.

4.6.9 L.F. CMRR ADJUSTMENT. C761 (C611), R767 (R617)

Set DC-GND-AC switches to DC, VOLTS/DIV to 10 μ V and VARIABLE to CAL. Apply simultaneously 1 kHz, 1 Vp-p square wave to both the INPUTs and obtain a display. Adjust C761 (C611) and R767 (R617) alternately to minimise the display amplitude. Increase the input amplitude to 5 Vp-p and re-adjust C761 (C611) and R767 (R617) if necessary to obtain minimum display amplitude.

4.6.10 ATTENUATOR RESPONSE

Connect the square wave generator to both the + and - INPUTs. Select range, input switch settings, square wave amplitude and frequency as given in the table, adjusting trimmer for the best square wave response.

Volts/Div	Switch Setting		Square Wave		Trimmer
	+ Input	- Input			
			Amplitude	Frequency	
5 mV	DC	GND	20 mV	1 kHz	C908
5 mV	GND	DC	20 mV	1 kHz	C912
50 mV	GND	DC	0.2 V	10 kHz	C915
50 mV	DC	GND	0.2 V	10 kHz	C905
0.5 V	DC	GND	2 V	10 kHz	C902
0.5 V	GND	DC	2 V	10 kHz	C918

4.6.11 INPUT CAPACITY ADJUSTMENT

Set + INPUT switch to GND, - INPUT to DC, VOLTS/DIV to 2 mV and VARIABLE to CAL. Apply 1 kHz square wave to the - INPUT via 10:1 probe and adjust the probe for optimum square wave response. Set, in turn, VOLTS/DIV to positions given in the following table and adjust the trimmer to obtain optimum square wave response.

VOLTS/DIV	TRIMMER
5 mV	C913
50 mV	C916
0.5 V	C919

Transfer the probe to + INPUT. Set + INPUT switch to DC and - INPUT switch to GND. Adjust the trimmers at the VOLTS/DIV settings given below for optimum square wave response.

VOLTS/DIV	TRIMMER
2 mV	C901
5 mV	C909
50 mV	C906
0.5 V	C903

4.6.12 H.F. CMRR ADJUSTMENT. C766 (C616), C771 (C621)

Set DC-GND-AC switches to DC, VOLTS/DIV to 10 μ V and VARIABLE to CAL. Apply 100 kHz, 5 Vp-p sine wave to

both the INPUTs and adjust C766 (C616) and C771 (C621) alternately, progressively reducing the displayed amplitude. It should be possible to eliminate the fundamental frequency, leaving only the second harmonic.

4.6.13 ATTENUATOR H.F. ADJUSTMENT. C912, C915, C918

Ensure that both the input switches are set to DC. Set VOLTS/DIV to 5 mV. Connect 100 kHz, 10 Vp-p sine wave to both the INPUTs, adjust C912 to minimize the display. Set VOLTS/DIV to 50 mV and adjust C915 to minimize the display. Set VOLTS/DIV to 0.5 V and adjust C918 to minimize the display. Disconnect the sine wave input.

4.7 HORIZONTAL AMPLIFIER

Note: For adjustment of R216, see paragraph 4.9.7.

4.7.1 D.C. ADJUSTMENTS. R218, R221

Select EXT HORIZ display mode and connect the meter, set to 10 V D.C. range, between 91/5 and chassis. Adjust FINE for zero meter reading. Connect the meter between 91/6 and chassis and adjust POSITION for zero reading.

Connect the meter, set to 100 V D.C. range, between the collectors of TR207 and TR208 and adjust R218 for zero reading.

Disconnect negative end of the meter, and connect it to chassis. Adjust R221 to obtain meter reading of 57 volts. Disconnect the meter.

PULL FINE for x5 MAG and adjust R205 to centre the spot horizontally. Push FINE in and adjust R218 to centre the spot. Check and re-adjust as required to bring the spot in the horizontal centre on x1 and x5 MAG.

4.7.2 GAIN ADJUSTMENT. R214

Check that supply voltage is at its nominal value. Apply a 1 kHz square wave of amplitude $5\text{ V} \pm 2\%$ to the EXT HORIZ socket. Adjust R214 for a horizontal deflection of exactly 5 divs. Disconnect the square wave generator.

4.7.3 PULSE RESPONSE OPTIMISATION. C202, C206, C208

Select x5 MAG by pulling FINE and display 100 kHz, 500 mV square wave, on the auxiliary oscilloscope using correctly terminated co-axial cable. Apply the same signal to the EXT HORIZ socket of the instrument under test. Connect the sweep output of the auxiliary oscilloscope to CH1 input and adjust CH1 controls to display a vertical time base of about 6 divs. amplitude. The 100 kHz square wave is now displayed horizontally on a vertical time base. Adjust C202, C206 and C208 to optimise the square wave response. (C206 and C208 are twisted wires).

4.8 TRIGGER AMPLIFIER

4.8.1 AUTO ADJUSTMENT. R7, R22

Select SWEEP, EXT, AUTO, — and SINGLE. Make sure that no external signal is connected to any of the front panel

sockets. Observe waveform at the collector of TR2 on an oscilloscope using 10:1 probe. The shape should be triangular with a fast transient superimposed upon it. Adjust R7 so that rising and falling parts of the triangular waveform are equal in duration. By turning R22, adjust amplitude of the sloping part of waveform to 80 mV, disregarding the fast transition.

Check also the duration of one cycle; this should be between 30 and 35 ms.

4.8.2 SCHMITT OPERATION CHECK

Apply 1 kHz 80 mVp-p sine wave to EXT HORIZ socket and check output at the collector of TR4. This should be a square wave of about 2 V amplitude and 1:1 mark-to-space ratio. Also check that 1:1 mark-to-space ratio occurs near the mid-position of the TRIG LEVEL control when either AC or DC of TRIG COUPLING is selected.

4.9 TIME BASE

4.9.1 GATE VOLTAGE ADJUSTMENT. R56

Set TIME/DIV switch to 0.5 μs and VARIABLE to CAL. Select SWEEP, EXT, —, AC and REP. Rotate TRIG LEVEL fully clockwise to inhibit FREE RUN. Make sure that no external signal is connected to any of the front panel sockets. Connect meter set to D.C. between 91/22 and chassis and adjust R56 to obtain zero reading. Disconnect the meter.

4.9.2 STABILITY ADJUSTMENT. R44

Select AUTO, +, CH1 and TRIG LEVEL to clockwise limit. Turn R44 to clockwise limit so that sweep free runs. Apply 1 kHz sine wave and obtain a display of about 4 divisions in amplitude at 1 ms/DIV sweep speed. Turn R44 through its entire range and note that a stable display is obtainable over a part of its range. Set R44 to the centre of the stable display range. Disconnect the sine wave generator.

4.9.3 HOLD-OFF TIME ADJUSTMENT. R72

Set TRIG LEVEL to FREE RUN. Connect test oscilloscope between 91/20 and chassis. Set TIME/DIV to 10 ms and adjust R72 for a hold-off time (time between end of one sweep and start of next) of 40 ms.

Check hold-off time on other TIME/DIV ranges as follows.

TIME/DIV	HOLD-OFF TIME
10 ms	40 ms
0.1 ms	$0.4 \pm 0.1\text{ ms}$
0.5 μs	$4.4 \mu\text{s} \pm 0.4 \mu\text{s}$

4.9.4 SINGLE SHOT ADJUSTMENT. R66

Select SINGLE, AC, EXT, — and SWEEP. Set R66 to clockwise limit. Turn R66 anticlockwise until the RESET indicator comes on. Note this position of R66. Now turn R66 clockwise and determine the position where the indicator is extinguished. Set R66 midway between the two noted positions. Set SWEEP MODE to REP and TIME/DIV to 50 ms. Display a 1 kHz, 100 mV sine wave signal and adjust TRIG LEVEL control for a synchronised display. Set SWEEP MODE to SINGLE and press RESET button. Each time RESET is pressed a single sweep should occur. Successive sweeps should coincide on the CRT screen.

4.9.5 SWEEP SPEED ADJUSTMENT. R63

Set TIME/DIV switch to 1 ms and VARIABLE to CAL. Display 1 ms markers from the time marker generator using + INPUT of CH1 and AC setting of the input switch. Adjust R63 for exactly one marker per division.

4.9.6 x5 GAIN ADJUSTMENT. R216

PULL FINE for x5 MAG. Set the markers to 100 μ s and adjust R216 to obtain exactly 2 markers per division. Push FINE in for x1. Disconnect the marker generator.

4.9.7 SPEED AND LINEARITY ADJUSTMENT. C55, C107

Apply 5 MHz sine wave to + INPUT and set the appropriate DC-GND-AC switch to AC. Set TIME/DIV to 0.5 μ s and obtain a locked display. Adjust C107 for minimum capacitance — this is indicated by maximum spacing between the peaks. Adjust C55 for best linearity. Disconnect the sine wave input and display 1 μ s markers. Ensure that the VARIABLE is set to CAL. Adjust C107 to obtain 1 marker over 2 divs.

4.9.8 SWEEP LENGTH ADJUSTMENT. R76

Free-run the time base, set TIME/DIV to 1 ms and adjust R76 to set the sweep length to 10.5 divisions.

4.9.9 INTERNAL TRIGGER ADJUSTMENT. R853 (R703)

Set the front panel controls as follows:

VOLTS/DIV & VARIABLE	2 mV & CAL
TIME/DIV & VARIABLE	0.1 ms & CAL
DISPLAY MODE	SWEEP
TRIG SOURCE & SLOPE	CH1 & +
TRIG COUPLING	AC
SWEEP MODE	REP
TRIG LEVEL	FREE RUN

Adjust trace position vertically to the centre of the screen; connect Avometer on 50 μ V D.C. range between 106/19 and 106/20 (91/19 and 91/20) and adjust R853 (R703) for zero reading. Disconnect Avometer. Display 1 kHz sine wave and check for satisfactory triggering on AC and DC coupling, + and — polarity.

4.10 CH2 HORIZ DISPLAY MODE

4.10.1 D.C. ADJUSTMENT. R688

Set VOLTS/DIV to 2 mV and INPUT switches to GND. Select SWEEP and set TRIG LEVEL to FREE RUN. Set POSITION to centre the trace. Select CH2 DISPLAY MODE. Connect meter, set to 100 V D.C. range, between collectors of TR207 and TR208 and adjust R687 for zero meter reading. Disconnect the negative end of the meter and connect it to chassis. Adjust R688 for a meter reading of 57 V. Select SWEEP and centralize the trace using vertical POSITION control. Select CH2 and adjust R687 to centre the spot horizontally.

4.10.2 GAIN ADJUSTMENT. R683

Set VOLTS/DIV to 1 mV. Display 5 mVp-p CAL signal horizontally. Adjust HORIZ SET GAIN R683 to set horizontal separation of the two spots to exactly 5 divs.

4.10.3 PHASE SHIFT. C628

Set VOLTS/DIV of CH1 and CH2 to 5 mV and select CH2 HORIZ DISPLAY MODE. Apply 100 kHz sine wave simultaneously to both channels. Adjust C628 so that the displayed loop degenerates into a straight line at 45° to the horizontal.

4.11 CROSS TALK ADJUSTMENT

Set CH1 and CH2 to 2 mV/DIV and display a 100 kHz square wave on CH1. Adjust the twisted wires on the CRT neck pins to eliminate breakthrough on the CH2 trace.

POSITION	R108 LOADING RESISTORS SELECTED BY WAFER 1F	TIMING RESISTORS SELECTED BY WAFER 2R	HOLD-OFF CAPACITORS SELECTED BY WAFER 1R	TIMING CAPACITORS SELECTED BY WAFER 2F
2 s	R101	R109, R111, R112, R113, R114, R115, R116, R117, R118	C104, C102	C108, C107
1 s	R101	R111, R112, R113, R114, R115, R116, R117, R118	C104, C102	C108, C107
0.5 s	R101	R112, R113, R114, R115, R116, R117, R118	C104, C102	C108, C107
0.2 s	R101, R102	R113, R114, R115, R116, R117, R118	C104, C102	C108, C107
0.1 s	R101, R102, R103	R114, R115, R116, R117, R118	C104, C102	C108, C107
50 ms	R101, R102, R103, R104	R115, R116, R117, R118	C104, C102	C108, C107
20 ms	R101, R102, R103, R104, R105	R116, R117, R118	C104, C102	C108, C107
10 ms	R101, R102, R103, R104, R105, R106	R117, R118	C104, C102	C108, C107
5 ms	R101	R112, R113, R114, R115, R116, R117, R118	C103, C102	C106, C107
2 ms	R101, R102	R113, R114, R115, R116, R117, R118	C103, C102	C106, C107
1 ms	R101, R102, R103	R114, R115, R116, R117, R118	C103, C102	C106, C107
0.5 ms	R101, R102, R103, R104	R115, R116, R117, R118	C103, C102	C106, C107
0.2 ms	R101, R102, R103, R104, R105	R116, R117, R118	C103, C102	C106, C107
0.1 ms	R101, R102, R103, R104, R105, R106	R117, R118	C103, C102	C106, C107
50 μ s	R101	R112, R113, R114, R115, R116, R117, R118	C101, C102	C105, C107
20 μ s	R101, R102	R113, R114, R115, R116, R117, R118	C101, C102	C105, C107
10 μ s	R101, R102, R103	R114, R115, R116, R117, R118	C101, C102	C105, C107
5 μ s	R101, R102, R103, R104	R115, R116, R117, R118	C101, C102	C105, C107
2 μ s	R101, R102, R103, R104, R105	R116, R117, R118	C101, C102	C105, C107
1 μ s	R101, R102, R103, R104, R105, R106	R117, R118	C101, C102	C105, C107
0.5 μ s		R118	C101, C102	C105, C107

Table 1

TIME/DIV SWITCH CONNEXIONS

SWITCH POSITION	ATTENUATION				GAIN SWITCHING	
	SELECTED BY WAFER 1F and R	SELECTED BY WAFER 2F and R	SELECTED BY WAFER 3F and R	SELECTED BY WAFER 4F and R	SELECTED BY WAFERS 5R and 6R	SELECTED BY WAFERS 5F and 6F
2 V	EYELET 87/3 NO:	EYELET 87/4 NO:	EYELET 87/9 NO:	EYELET 87/10 NO:	R915, R916, R917 R918, R919	R921, R922 C922, C923
1 V	87/3	87/4	87/9	87/10	R915, R916, R917 R918, R919	R922, C923
0.5 V	87/3	87/4	87/9	87/10	R915, R916, R917 R918, R919	
0.2 V	87/5	87/6	87/11	87/12	R915, R916, R917 R918, R919	R921, R922 C922, C923
0.1 V	87/5	87/6	87/11	87/12	R915, R916, R917 R918, R919	R922, C923
50 mV	87/5	87/6	87/11	87/12	R915, R916, R917 R918, R919	
20 mV	87/7	87/8	87/13	87/14	R915, R916, R917 R918, R919	R921, R922 C922, C923
10 mV	87/7	87/8	87/13	87/14	R915, R916, R917 R918, R919	R922, C923
5 mV	87/7	87/8	87/13	87/14	R915, R916, R917 R918, R919	
2 mV					R915, R916, R917 R918, R919	R921, R922 C922, C923
1 mV					R915, R916, R917 R918, R919	R922, C923
0.5 mV					R915, R916, R917 R918, R919	
0.2 mV					R916, R917, R918 R919	
0.1 mV					R917, R918, R919	
50 μ V					R918, R919	
20 μ V					R919	
10 μ V						

Table 2 VOLTS/DIV SWITCH CONNEXIONS

CHAPTER 5

COMPONENT LIST

Values of resistors are stated in ohms or multiples of ohms; ratings at 70°C are in watts or sub-multiples of watts. Values of capacitors are stated in sub-multiples of farads; ratings at 70°C are in volts or kilovolts.

Whenever possible, exact replacements for components should be used, although locally available alternatives may be satisfactory for standard components.

Any order for replacement parts should include:

- | | | | |
|----|-----------------------------|----|-----------------------|
| 1. | Instrument type | 4. | Component part number |
| 2. | Instrument serial number | 5. | Component value |
| 3. | Component circuit reference | | |

CIRCUIT REFERENCE BLOCKS

The table below gives the blocks of circuit references, so that the reader can relate the items listed in this chapter and their location in the circuitry and printed circuit boards in Chapter 6.

Circuit Reference		Circuit	Fig	P.C. Board No
From	To			
1	40	Trigger Amplifier	5	91
41	100	Sweep & Bright Up	6	91
101	150	Time/Div Switch	7	102
200	250	Horizontal Amplifier	8	91
301	400	CRT	9	91
401	450	Power Supply	9	91
			11	77, 92
500	510	Voltage Stabiliser	10	91
601	749	Channel 2 "Y" Amplifier	3	90
751	900	Channel 1 "Y" Amplifier	2	106
901	950	Volt/Div Switch	4	87
1001	1010	Calibrator	10	91

ABBREVIATIONS

C	Carbon	Ge	Germanium	Se	Selenium
CP	Carbon preset			Si	Silicon
CV	Carbon variable	MF	Metal film	SM	Silver mica
CER	Ceramic	MO	Metal oxide	WW	Wire-wound
CT	Ceramic trimmer	PE	Polyester	WWP	Wire-wound preset
CM	Cermet thick film	PP	Polypropylene	WWV	Wire-wound variable
E	Electrolytic	PS	Polystyrene		

TELEQUIPMENT, division of TEKTRONIX U.K. LIMITED

313 Chase Road Southgate London N14 6JJ England

Telephone: 01-882 1166 Telex: 262004 Cables: TELEQUIPT LONDON N14

All requests for repairs or replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service.

ELECTRICAL

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE F	TYPE	TOL %	RATING V
C1	285-0946-00	470 n	PE	20	250
C2	285-0946-00	470 n	PE	20	250
C4	285-0796-00	100 n	PE	20	250
C5	281-0735-00	3.3 p	CER	0.1 p	500
C6	285-0915-00	100 n	PE	20	100
C7	285-0845-00	68 p	PS	2 p	350
C8	285-0854-00	100 p	PS	2 p	350
C9	285-0779-00	470 n	PE	20	100

C41	285-0854-00	100 p	PS	2 p	350
C42	285-0845-00	68 p	PS	2 p	350
C43	285-0867-00	20 p	PS	1 p	350
C44	281-0710-00	10 n	CER		250
C45	281-0710-00	10 n	CER		250
C46	285-0866-00	10 p	PS	1 p	350
C47	281-0744-00	6.8 p	CER	0.5 p	750
C48	285-0842-00	15 p	PS	1 p	350
C49	285-0796-00	100 n	PE	20	250
C50	281-0710-00	10 n	CER		250
C51	285-0874-00	470 p	PS	5	125
C52	285-0869-00	47 p	PS	2 p	350
C53	285-0779-00	470 n	PE	20	100
C54	281-0710-00	10 n	CER		250
C55	281-0156-00	1.4-6.4 p	PP		500

C101	285-0786-00	33 p	PS	2 p	350
C102	285-0776-00	27 p	PS	1 p	350
C103	285-0770-00	4.7 n	PS	1	125
C104	285-0774-00	470 n	PE	2	63
C105	285-0973-00	82 p	PS	1 p	160
C106	285-0942-00	10 n	PE	1	125
C107	281-0137-00	6-30 p	CT		350
C108	285-0943-00	1 μ	PE	1	63

CIR REF	PART NUMBER	VALUE F	DESCRIPTION		
			TYPE	TOL %	RATING V
C201	285-0779-00	470 n	PE	20	100
C202	281-0155-00	2-22 p	PP		500
C203	285-0845-00	68 p	PS	2 p	350
C204	285-0779-00	470 n	PE	20	100
C205	281-0731-00	5.6 p	CER	0.5 p	750
C206		Twisted wire			
C207	285-0915-00	100 n	PE	20	100
C208		Twisted wire			
C209	285-0796-00	100 n	PE	20	250
C211	285-0920-00	56 p	PS	2 p	350

C301	281-0682-00	20 n	CER		2 k
C302	281-0710-00	10 n	CER		250
C303	281-0710-00	10 n	CER		250
C304	281-0710-00	10 n	CER		250
C305	281-0710-00	10 n	CER		250
C306	281-0710-00	10 n	CER		250
C307	281-0710-00	10 n	CER		250
C308	281-0682-00	20 n	CER		2 k
C309	281-0682-00	20 n	CER		2 k
C311	281-0710-00	10 n	CER		250

C401	285-0779-00	470 n	PE	20	100
C402	281-0706-00	30 n	CER		1.5 k
C403	281-0682-00	20 n	CER		2 k
C405	290-0478-00	470 μ	E		63
C406	290-0540-00	15 μ	E		450
C407	290-0540-00	15 μ	E		450
C408	290-0540-00	15 μ	E		450
C409	290-0478-00	470 μ	E		63
C410	285-0984-00	100 n	PE	20	2 k

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE F	TYPE	TOL %	RATING V
C411	285-0984-00	100 n	PE	20	2 k
C412	290-0541-00	2.2 m	E		16
C413	290-0579-00	1.0 m	E		16
C414	290-0579-00	1.0 m	E		16
C415	290-0579-00	1.0 m	E		16
C416	290-0579-00	1.0 m	E		16
C417	290-0579-00	1.0 m	E		16
C418	290-0503-00	330 μ	E		160

C421 290-0567-00 33 μ E 100

C501 281-0710-00 10 n CER 250
C502 281-0710-00 10 n CER 250
C503 285-0915-00 100 n PE 20 100
C504 285-0915-00 100 n PE 20 100

C603 285-0875-00 100 n PE 2 400
C604 285-0875-00 100 n PE 2 400
C605 285-0940-00 12 p PS 1 p 350
C606 285-0842-00 15 p PS 1 p 350
C607 285-0944-00 4.7 n PS 1 500
C608 285-0944-00 4.7 n PS 1 500
C609 281-0710-00 10 n CER 250
C610 281-0710-00 10 n CER 250
C611 281-0156-00 1.4-6.4 p PP 500
C612 281-0711-00 3.9 p CER 0.25 p 750
C613 281-0155-00 2-22 p PP 500
C614 281-0155-00 2-22 p PP 500

C616 281-0155-00 2-22 p PP 500
C617 281-0710-00 10 n CER 250
C618 281-0676-00 2.2 p CER 0.1 p 500
C619 281-0710-00 10 n CER 250
C620 281-0710-00 10 n CER 250
C621 281-0156-00 1.4-6.4 p PP 500
C622 281-0676-00 2.2 p CER 0.1 p 500
C623 285-0795-00 220 n PE 20 250
C624 281-0710-00 10 n CER 250

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE F	TYPE	TOL %	RATING V
C625	281-0156-00	1.4-6.4 p	PP		500
C626	285-0850-00	1 n	PS	5	125
C627	285-0850-00	1 n	PS	5	125
C628	281-0155-00	2-22 p	PP		500
C631	285-0842-00	15 p	PS	1 p	350
C632	285-0842-00	15 p	PS	1 p	350

C753 285-0875-00 100 n PE 2 400
C754 285-0875-00 100 n PE 2 400
C755 285-0940-00 12 p PS 1 p 350
C756 285-0942-00 15 p PS 1 p 350
C757 285-0944-00 4.7 n PS 1 500
C758 285-0944-00 4.7 n PS 1 500
C759 281-0710-00 10 n CER 250
C760 281-0710-00 10 n CER 250
C761 281-0156-00 1.4-6.4 p PP 500
C762 281-0711-00 3.9 p CER 0.25 p 750
C763 281-0155-00 2-22 p PP 500
C764 281-0155-00 2-22 p PP 500

C766 281-0155-00 2-22 p PP 500
C767 281-0710-00 10 n CER 250
C768 281-0676-00 2.2 p CER 0.1 p 500
C769 281-0710-00 10 n CER 250
C770 281-0710-00 10 n CER 250
C771 281-0156-00 1.4-6.4 p PP 500
C772 281-0676-00 2.2 p CER 0.1 p 500
C773 285-0795-00 220 n PE 20 250
C774 281-0710-00 10 n CER 250
C775 281-0156-00 1.4-6.4 p PP 500
C776 285-0850-00 1 n PS 125
C777 285-0850-00 1 n PS 125

C781 285-0842-00 15 p PS 1 p 350
C782 285-0842-00 15 p PS 1 p 350

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE F	TYPE	TOL %	RATING V
*C901	281-0155-00	2-12 p	PP		500
*C902	281-0156-00	1,4-6,4 p	PP		500
*C903	281-0155-00	2-22 p	PP		500
*C904	285-0886-00	4,7 n	PE	20	100
*C905	281-0156-00	1,4-6,4 p	PP		500
*C906	281-0155-00	2-22 p	PP		500
*C907	285-0874-00	470 p	PS	5	125
*C908	281-0155-00	2-22 p	PP		500
*C909	281-0154-00	2-12 p	PP		500
*C911	285-0872-00	180 p	PS	2	350
*C912	281-0155-00	2-22 p	PP		500
*C913	281-0154-00	2-12 p	PP		500
*C914	285-0872-00	180 p	PS	2	350

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE F	TYPE	TOL %	RATING V
*C915	281-0156-00	1,4-6,4 p	PP		500
*C916	281-0155-00	2-22 p	PP		500
*C917	285-0874-00	470 p	PS	5	125
*C918	281-0156-00	1,4-6,4 p	PP		500
*C919	281-0155-00	2-22 p	PP		500
*C921	285-0886-00	4,7 n	PE	20	100
*C922	285-0866-00	10 p	PS	1 p	350
*C923	281-0712-00	5 p	CER	0,25 p	750

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING
D1	152-0062-01		1N914/1N4148	Si		75 V
D2	152-0062-01		1N914/1N4148	Si		75 V
D3	152-0468-00		BAX 16	Si		150 V
D4	152-0468-00		BAX 16	Si		150 V

D41	152-0062-01		1N914/1N4148	Si		75 V
D42	152-0370-00		AAY30/AAY42	Ge		75 V
D43	152-0062-01		1N914/1N4148	Si		75 V
D44	152-0483-00		Telequipment spec.	Si		10 V
D45	152-0062-01		1N914/1N4148	Si		75 V
D46	152-0062-01		1N914/1N4148	Si		75 V
D47	152-0062-01		1N914/1N4148	Si		75 V
D48	152-0468-00		BAX 16	Si		150 V
D49	152-0468-00		BAX 16	Si		150 V
D51	152-0062-01		1N914/1N4148	Si		75 V
D52	152-0062-01		1N914/1N4148	Si		75 V

* Two per instrument.

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING
D201	152-0062-01		1N914/1N4148	Si		75 V
D202	152-0062-01		1N914/1N4148	Si		75 V
D203	152-0062-01		1N914/1N4148	Si		75 V
D204	152-0062-01		1N914/1N4148	Si		75 V
D205	152-0062-01		1N914/1N4148	Si		75 V
D206	152-0062-01		1N914/1N4148	Si		75 V
D207	152-0062-01		1N914/1N4148	Si		75 V
D208	152-0062-01		1N914/1N4148	Si		75 V

D301	152-0431-00	33 V	Zener		5	700 mW
D302	152-0432-00	62 V	Zener		5	700 mW

D401	152-0374-00	3,4 kV	Rectifier	Se		600 μ A
D402	152-0374-00	3,4 kV	Rectifier	Se		600 μ A
D405	152-0339-00	50 V	Rectifier	Si		500 mA
D406	152-0339-00	50 V	Rectifier	Si		500 mA
D407	152-0339-00	50 V	Rectifier	Si		500 mA
D408	152-0339-00	50 V	Rectifier	Si		500 mA
D409	152-0515-00	6 kV	Rectifier	Si		8 mA
D410	152-0374-00	3,4 kV	Rectifier	Se		600 μ A
D411	152-0374-00	3,4 kV	Rectifier	Se		600 μ A
D412	152-0341-00	450 V	Rectifier	Si		500 mA
D415	152-0341-00	450 V	Rectifier	Si		500 mA

D501	152-0432-00	62 V	Zener		5	700 mW
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CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING
D606	152-0324-00		Tektronix spec.			
D607	152-0324-00		Tektronix spec.			
D608	152-0324-00		Tektronix spec.			
D609	152-0324-00		Tektronix spec.			
D611	152-0348-00	6.2 V	Zener		5	330 mW
D612	152-0348-00	6.2 V	Zener		5	330 mW
D613	152-0062-01		1N914/1N4148	Si		75 V
D614	152-0062-01		1N914/1N4148	Si		75 V
D616	152-0477-00	27 V	Zener		5	700 mW
D617	152-0062-01		1N914/1N4148	Si		75 V
D618	152-0062-01		1N914/1N4148	Si		75 V
D756	152-0324-00		Tektronix spec.			
D757	152-0324-00		Tektronix spec.			
D758	152-0324-00		Tektronix spec.			
D759	152-0324-00		Tektronix spec.			
D761	152-0348-00	6.2 V	Zener		5	330 mW
D762	152-0348-00	6.2 V	Zener		5	330 mW
D763	152-0062-01		1N914/1N4148	Si		75 V
D764	152-0062-01		1N914/1N4148	Si		75 V
D766	152-0477-00	27 V	Zener		5	700 mW
D1001	152-0062-01		1N914/1N4148	Si		75 V
D1002	152-0421-00	3.3 V	Zener		5	330 mW
D1003	152-0062-01		1N914/1N4148	Si		75 V
D1004	152-0062-01		1N914/1N4148	Si		75 V

CIR REF	PART NUMBER	VALUE	DESCRIPTION			TYPE	TOL %	RATING	
F401	159-0077-00	250 mA (200-250 V)	1.25 in. delay						
	159-0079-00	500 mA (100-125 V)	1.25 in. delay						
FB	256-0597-00		Ferrite bead Mullard FX1115						
L301	108-0656-00	129 Ω	Trace rotation coil 170 turns						
L601	108-0722-00	13 μ H	Fixed inductor						
L751	108-0722-00	13 μ H	Fixed inductor						
LP401	150-0080-00	14 V	LES					560 mW	
LP402	150-0095-00	14 V	LES					750 mW	
LP403	150-0095-00	14 V	LES					750 mW	

CIR REF	PART NUMBER	VALUE ohms	DESCRIPTION			TYPE	TOL %	RATING W	
			TYPE	TOL	RATING				
R1	317-0564-01	560 k	C	5	125 m				
R2	311-1184-00	100 k	CV	20	250 m				
R3	317-0394-01	390 k	C	5	125 m				
R4	317-0105-01	1 M	C	5	125 m				

CIR REF	PART NUMBER	VALUE ohms	DESCRIPTION			TYPE	TOL %	RATING W	
			TYPE	TOL	RATING				
R6	317-0204-01	200 k	C	5	125 m				
R7	311-0765-00	100 k	CP	20	250 m				
R8	317-0104-01	100 k	C	5	125 m				
R9	317-0104-01	100 k	C	5	125 m				

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
R11	316-0473-01	47 k	C	10	250 m
R12	317-0154-01	150 k	C	5	125 m
R13	317-0104-01	100 k	C	5	125 m
R14	317-0104-01	100 k	C	5	125 m
R15	317-0104-01	100 k	C	5	125 m
R16	316-0473-01	47 k	C	10	250 m
R17	317-0182-01	1.8 k	C	5	125 m
R18	317-0471-01	470	C	5	125 m
R19	317-0332-01	3.3 k	C	5	125 m
R21	317-0472-01	4.7 k	C	5	125 m
R22	311-0717-00	220	CP	20	250 m
R23	317-0681-01	680	C	5	125 m
R24	317-0332-01	3.3 k	C	5	125 m
R25	317-0472-01	4.7 k	C	5	125 m
R26	317-0304-01	300 k	C	5	125 m
R27	317-0304-01	300 k	C	5	125 m
R28	317-0223-01	22 k	C	5	125 m
R29	317-0243-01	24 k	C	5	125 m
R31	307-0144-00	10 k	MO	5	1.5
R41	321-0298-48	12.4 k	MF	1	125 m
R42	321-0847-48	3.3 k	MF	1	125 m
R43	317-0682-01	6.8 k	C	5	125 m
R44	311-1091-00	6.8 k	CP	20	250 m
R45	317-0332-01	3.3 k	C	5	125 m
R46	321-1200-48	1.2 k	MF	1	125 m
R47	317-0152-01	1.5 k	C	5	125 m
R48	317-0561-01	560	C	5	125 m
R49	317-0153-01	15 k	C	5	125 m
R50	317-0222-01	2.2 k	C	5	125 m
R51	317-0472-01	4.7 k	C	5	125 m
R52	317-0102-01	1 k	C	5	125 m
R53	317-0473-01	47 k	C	5	125 m
R54	317-0101-01	100	C	5	125 m
R55	317-0101-01	100	C	5	125 m
R56	311-0735-00	10 k	CP	20	250 m
R57	317-0223-01	22 k	C	5	125 m
R58	317-0101-01	100	C	5	125 m
R59	315-0563-01	56 k	C	5	250 m
R61	317-0244-01	240 k	C	5	125 m
R62	317-0183-01	18 k	C	5	125 m
R63	311-0756-00	47 k	CP	20	250 m
R64	317-0823-01	82 k	C	5	125 m
R65	317-0823-01	82 k	C	5	125 m
R66	311-0791-00	220 k	CP	20	250 m

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
R67	317-0224-01	220 k	C	5	125 m
R68	317-0472-01	4.7 k	C	5	125 m
R69	317-0273-01	27 k	C	5	125 m
R70	317-0471-01	470	C	5	125 m
R71	317-0152-01	1.5 k	C	5	125 m
R72	311-0851-00	1 k	CP	20	250 m
R73	317-0105-01	1 M	C	5	125 m
R74	317-0102-01	1 k	C	5	125 m
R75	317-0183-01	18 k	C	5	125 m
R76	311-0756-00	47 k	CP	20	250 m
R77	317-0822-01	8.2 k	C	5	125 m
R78	317-0243-01	24 k	C	5	125 m
R79	317-0123-01	12 k	C	5	125 m
R80	317-0473-01	47 k	C	5	125 m
R81	317-0822-01	8.2 k	C	5	125 m
R82	303-0822-01	8.2 k	C	5	1
R83	303-0822-01	8.2 k	C	5	1
R84	317-0101-01	100	C	5	125 m
R85	317-0105-01	1 M	C	5	125 m
R86	317-0104-01	100 k	C	5	125 m
R87	317-0682-01	6.8 k	C	5	125 m
R88	317-0102-01	1 k	C	5	125 m
R89	317-0222-01	2.2 k	C	5	125 m
R101	321-0877-48	62 k	MF	1	125 m
R102	317-0242-01	2.4 k	C	5	125 m
R103	317-0302-01	3 k	C	5	125 m
R104	317-0392-01	3.9 k	C	5	125 m
R105	317-0153-01	15 k	C	5	125 m
R106	321-0351-48	44.2 k	MF	1	125 m
R107	316-0394-01	390 k	C	10	250 m
R108	311-1186-00	100 k	CV	20	250 m
R109	324-0585-40	12.1 M	MF	1	1
R111	324-0556-40	6.04 M	MF	1	1
R112	324-0614-40	3.6 M	MF	1	1
R113	324-0489-40	1.21 M	MF	1	250 m
R114	321-0460-48	604 k	MF	1	125 m
R115	321-0935-48	360 k	MF	1	125 m
R116	321-0393-48	121 k	MF	1	125 m
R117	321-0364-48	60.4 k	MF	1	125 m
R118	321-0364-48	60.4 k	MF	1	125 m
*{R200	311-1088-00	100 k	CV	20	250 m
{R201	311-1088-00	100 k	CV	20	250 m
R202	317-0105-01	1 M	C	5	125 m
R203	317-0204-01	200 k	C	5	125 m
R204	317-0153-01	15 k	C	5	125 m

* Dual concentric pot.

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
R505	321-0318-48	20 k	MF	1	125 m
R506	317-0332-01	3.3 k	C	5	125 m
R507	317-0105-01	1 M	C	5	125 m
R608	317-0100-01	10	C	5	125 m
R609	317-0100-01	10	C	5	125 m
R611	321-0485-48	1.1 M	MF	1	125 m
R612	321-0485-48	1.1 M	MF	1	125 m
R613	316-0106-03	10 M	C	10	250 m
R614	316-0106-03	10 M	C	10	250 m
R615	315-0221-02	220	C	5	250 m
R616	315-0221-02	220	C	5	250 m
R617	311-0735-00	10 k	CP	20	250 m
R618	315-0105-02	1 M	C	5	250 m
R619	315-0105-02	1 M	C	5	250 m
R621	321-0385-48	100 k	MF	1	125 m
R622	321-0383-48	95.3 k	MF	1	125 m
R623	311-0910-00	2.2 M	CP	20	250 m
R624	311-0910-00	2.2 M	CP	20	250 m
R625	316-0105-01	1 M	C	10	250 m
R626	317-0104-01	100 k	C	5	125 m
R627	317-0102-01	1 k	C	5	125 m
R628	317-0102-01	1 k	C	5	125 m
R629	321-0641-48	1.8 k	MF	1	125 m
R631	311-0995-00	680	CP	20	250 m
R632	321-1257-48	4.7 k	MF	1	125 m
R633	317-0103-01	10 k	C	5	125 m
R634	321-0845-48	2.7 k	MF	1	125 m
R635	321-0641-48	1.8 k	MF	1	125 m
R636	321-1257-48	4.7 k	MF	1	125 m
R637	321-0849-48	22 k	MF	1	125 m
R638	317-0104-01	100 k	C	5	125 m
R639	311-0809-00	1 M	CP	20	250 m
R641	316-0105-01	1 M	C	10	250 m
R642	321-0874-48	39 k	MF	1	125 m
R643	311-0765-00	100 k	CP	20	250 m
R644	321-0356-48	49.9 k	MF	1	125 m
R645	321-0356-48	49.9 k	MF	1	125 m
R646	311-1089-00	250	CV	20	250 m

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
R648	317-0101-01	100	C	5	125 m
R649	317-0101-01	100	C	5	125 m
R650	315-0101-02	100	C	5	250 m
R651	317-0471-01	470	C	5	125 m
R652	311-1111-00	3.3 k	CV	20	250 m
R653	317-0182-01	1.8 k	C	5	125 m
R654	317-0182-01	1.8 k	C	5	125 m
R655	311-0894-00	330	CP	20	250 m
R656	317-0101-01	100	C	5	125 m
R657	317-0101-01	100	C	5	125 m
R658	317-0470-01	47	C	5	125 m
R659	315-0512-02	5.1 k	C	5	250 m
R660	315-0512-02	5.1 k	C	5	250 m
R661	311-0851-00	1 k	CP	20	250 m
R662	317-0104-01	100 k	C	5	125 m
R663	317-0224-01	220 k	C	5	125 m
R664	311-1028-00	100 k	CV	20	250 m
R665	311-0756-00	47 k	CP	20	250 m
R666	315-0562-02	5.6 k	C	5	250 m
R667	315-0472-02	4.7 k	C	5	250 m
R668	317-0103-01	10 k	C	5	125 m
R669	317-0562-01	5.6 k	C	5	125 m
R671	317-0512-01	5.1 k	C	5	125 m
R672	317-0512-01	5.1 k	C	5	125 m
R673	317-0123-01	12 k	C	5	125 m
R674	317-0512-01	5.1 k	C	5	125 m
R675	317-0512-01	5.1 k	C	5	125 m
R676	317-0821-01	820	C	5	125 m
R677	317-0821-01	820	C	5	125 m
R678	317-0562-01	5.6 k	C	5	125 m
R679	317-0562-01	5.6 k	C	5	125 m
R682	317-0821-00	820	C	5	125 m
R683	311-1185-00	1 k	CV	20	250 m
R685	317-0273-01	27 k	C	5	125 m
R686	317-0273-01	27 k	C	5	125 m
R687	311-0735-00	10 k	CP	20	250 m
R688	311-0802-00	4.7 k	CP	20	250 m
R691	317-0222-01	2.2 k	C	5	125 m
R692	317-0222-01	2.2 k	C	5	125 m
R693	317-0330-01	33	C	5	125 m
R694	311-1102-00	100	CV	20	250 m
R695	317-0330-01	33	C	5	125 m
R696	303-0472-01	4.7 k	C	5	1
R697	303-0472-01	4.7 k	C	5	1
R698	317-0243-01	24 k	C	5	125 m
R699	317-0153-01	15 k	C	5	125 m
R700	317-0153-01	15 k	C	5	125 m
R701	317-0243-01	24 k	C	5	125 m
R702	317-0221-01	220	C	5	125 m
R703	311-0735-00	10 k	CP	20	250 m

CIR REF	PART NUMBER	VALUE ohms	DESCRIPTION		
			TYPE	TOL %	RATING W
R704	317-0221-01	220	C	5	125 m
R758	317-0100-01	10	C	5	125 m
R759	317-0100-01	10	C	5	125 m
R761	321-0485-48	1.1 M	MF	1	125 m
R762	321-0485-48	1.1 M	MF	1	125 m
R763	316-0106-03	10 M	C	10	250 m
R764	316-0106-03	10 M	C	10	250 m
R765	315-0221-02	220	C	5	250 m
R766	315-0221-02	220	C	5	250 m
R767	311-0735-00	10 k	CP	20	250 m
R768	315-0105-02	1 M	C	5	250 m
R769	315-0105-02	1 M	C	5	250 m
R771	321-0385-48	100 k	MF	1	125 m
R772	321-0383-48	95.3 k	MF	1	125 m
R773	311-0910-00	2.2 M	CP	20	250 m
R774	311-0910-00	2.2 M	CP	20	250 m
R775	316-0105-01	1 M	C	10	250 m
R776	317-0104-01	100 k	C	5	125 m
R777	317-0102-01	1 k	C	5	125 m
R778	317-0102-01	1 k	C	5	125 m
R779	321-0641-48	1.8 k	MF	1	125 m
R781	311-0995-00	680	CP	20	250 m
R782	321-1257-48	4.7 k	MF	1	125 m
R783	317-0103-01	10 k	C	5	125 m
R784	321-0845-48	2.7 k	MF	1	125 m
R785	321-0641-48	1.8 k	MF	1	125 m
R786	321-1257-48	4.7 k	MF	1	125 m
R787	321-0849-48	22 k	MF	1	125 m
R788	317-0104-01	100 k	C	5	125 m
R789	311-0809-00	1 M	CP	20	250 m
R791	316-0104-01	100 k	C	10	250 m
R792	321-0874-48	39 k	MF	1	125 m
R793	311-0765-00	100 k	CP	20	250 m
R794	321-0356-48	49.9 k	MF	1	125 m
R795	321-0356-48	49.9 k	MF	1	125 m
R796	311-1089-00	250	CV	20	250 m
R798	317-0101-01	100	C	5	125 m

CIR REF	PART NUMBER	VALUE ohms	DESCRIPTION		
			TYPE	TOL %	RATING W
R799	317-0101-01	100	C	5	125 m
R800	315-0101-02	100	C	5	250 m
R801	317-0471-01	470	C	5	125 m
R802	311-1111-00	3.3 k	CV	20	250 m
R803	317-0182-01	1.8 k	C	5	125 m
R804	317-0182-01	1.8 k	C	5	125 m
R805	311-0894-00	330	CP	20	250 m
R806	317-0101-01	100	C	5	125 m
R807	317-0101-01	100	C	5	125 m
R808	317-0470-01	47	C	5	125 m
R809	315-0512-02	5.1 k	C	5	250 m
R810	315-0512-02	5.1 k	C	5	250 m
R811	311-0851-00	1 k	CP	20	250 m
R812	317-0104-01	100 k	C	5	125 m
R813	317-0224-01	220 k	C	5	125 m
R814	311-1028-00	100 k	CV	20	250 m
R815	311-0756-00	47 k	CP	20	250 m
R816	315-0562-02	5.6 k	C	5	250 m
R817	315-0472-02	4.7 k	C	5	250 m
R818	317-0103-01	10 k	C	5	125 m
R819	317-0562-01	5.6 k	C	5	125 m
R821	317-0512-01	5.1 k	C	5	125 m
R822	317-0512-01	5.1 k	C	5	125 m
R823	317-0123-01	12 k	C	5	125 m
R824	317-0512-01	5.1 k	C	5	125 m
R825	317-0512-01	5.1 k	C	5	125 m
R826	317-0821-01	820	C	5	125 m
R827	317-0821-01	820	C	5	125 m
R828	317-0562-01	5.6 k	C	5	125 m
R829	317-0562-01	5.6 k	C	5	125 m
R841	317-0222-01	2.2 k	C	5	125 m
R842	317-0222-01	2.2 k	C	5	125 m
R843	317-0330-01	33	C	5	125 m
R844	311-1102-00	100	CV	20	250 m
R845	317-0330-01	33	C	5	125 m
R846	303-0472-01	4.7 k	C	5	1
R847	303-0472-01	4.7 k	C	5	1
R848	317-0243-01	24 k	C	5	125 m
R849	317-0153-01	15 k	C	5	125 m
R850	317-0153-01	15 k	C	5	125 m
R851	317-0243-01	24 k	C	5	125 m
R852	317-0221-01	220	C	5	125 m
R853	311-0735-00	10 k	CP	20	250 m
R854	317-0221-01	220	C	5	125 m

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
*R901	321-0481-48	1 M	MF	1	125 m
*R902	321-0191-48	953	MF	1	125 m
*R903	311-0895-00	150	CP	20	250 m
*R904A	310-0678-00	990 k	CM	1	250 m
B		10.1 k			
*R905	311-0913-00	1.5 k	CP	20	250 m
*R906	317-0224-01	200 k	C	5	125 m
*R907A	310-0679-00	900 k	CM	1	250 m
B		111 k			
*R908	311-0850-00	15 k	CP	20	250 m
*R909	307-0233-00	2.2 M	C	10	125 m
*R911A	310-0679-00	900 k	CM	1	250 m
B		111 k			
*R912A	310-0678-00	990 k	CM	1	250 m
B		10.1 k			
*R913	321-0481-48	1 M	MF	1	125 m

CIR REF	PART NUMBER	DESCRIPTION			
		VALUE ohms	TYPE	TOL %	RATING W
*R914	321-0193-48	1 k	MF	1	125 m
*R915	321-0847-48	3.3 k	MF	1	125 m
*R916	321-0289-48	10 k	MF	1	125 m
*R917	321-0318-48	20 k	MF	1	125 m
*R918	321-0851-48	33 k	MF	1	125 m
*R919	321-0385-48	100 k	MF	1	125 m
*R921	321-0193-48	1 k	MF	1	125 m
*R922	321-0222-48	2 k	MF	1	125 m
R1001	321-1037-48	24	MF	1	125 m
R1002	321-0277-48	7.5 k	MF	1	125 m
R1003	311-1250-00	4.7 k	WWP	10	1
R1004	317-0822-01	8.2 k	C	5	125 m
R1005	317-0103-01	10 k	C	5	125 m

CIR REF	PART NUMBER	DESCRIPTION
S1	260-1175-00	Push (2 — button)
S2	260-1176-00	Push (2 — button)
S3	260-1177-00	Push (4 — button)
S4	260-1178-00	Push (3 — button)
S5	260-1267-00	Rotary (21 — position)
S6	311-1184-00	Rotary (with R2)
S201	311-1088-00	Pull (with 200 & R201)

CIR REF	PART NUMBER	DESCRIPTION
S601	260-1271-00	Lever (3 — position)
S602	260-1271-00	Lever (3 — position)
S603	311-1111-00	Pull (with R652)
S751	260-1271-00	Lever (3 — position)
S752	260-1271-00	Lever (3 — position)
S753	311-1111-00	Pull (with R802)
*S901	260-1202-00	Rotary (17 — position)
T401	120-0674-00	Power Transformer

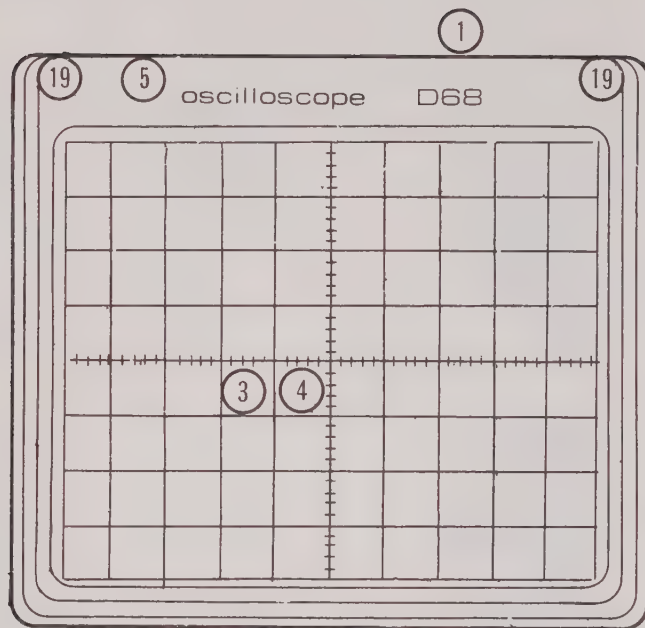
CIR REF	PART NUMBER	VALUE ohms	TYPE	TOL %	RATING W
TH601	307-0258-00	130 at 25°C	Thermistor	20	500 m
TH751	307-0258-00	130 at 25°C	Thermistor	20	500 m

*Two per instrument.

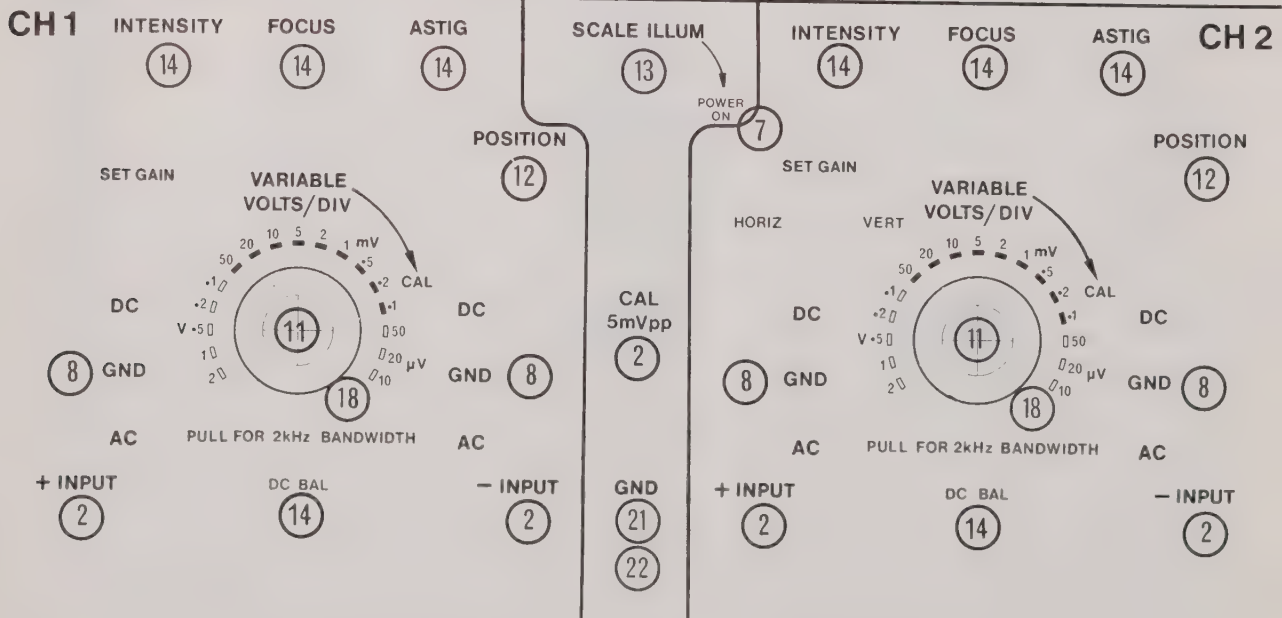
CIR REF	PART NUMBER	DESCRIPTION		TYPE
TR1	151-0317-00	BC109C	Si	NPN
TR2	151-0317-00	BC109C	Si	NPN
TR3	151-0127-02	BSX 20/2N2369	Si	NPN
TR4	151-0127-02	BSX 20/2N2369	Si	NPN
TR5	151-0317-00	BC 109C	Si	NPN
TR41	151-0127-02	BSX 20/2N2369	Si	NPN
TR42	151-0127-02	BSX 20/2N2369	Si	NPN
TR43	151-1052-00	Telequipment spec.	Si	N-channel
TR44	151-0317-00	BC109C	Si	NPN
TR45	151-0317-00	BC109C	Si	NPN
TR46	151-0242-00	2N3904	Si	NPN
TR47	151-0257-00	BF305/2N1990	Si	NPN
TR48	151-0257-00	BF305/2N1990	Si	NPN
TR201	151-0326-02	BC107	Si	NPN
TR202	151-0326-02	BC107	Si	NPN
TR203	151-0320-00	BFX48/MPS 6518	Si	PNP
TR204	151-0320-00	BFX48/MPS 6518	Si	PNP
TR205	151-0320-00	BFX48/MPS 6518	Si	PNP
TR206	151-0320-00	BFX48/MPS 6518	Si	PNP
TR207	151-0257-00	BF305/2N1990	Si	NPN
TR208	151-0257-00	BF305/2N1990	Si	NPN

CIR REF	PART NUMBER	DESCRIPTION		TYPE
TR501	151-0320-00	BFX48/MPS 6518	Si	PNP
TR502	151-0127-02	BSX 20/2N2369	Si	NPN
TR503	151-0320-00	BFX48/MPS6518	Si	PNP
TR601A) B)	151-1027-00	Dual FET Tektronix spec.	Si	N-channel
TR603	151-0320-00	BFX48/MPS 6518	Si	PNP
TR604	151-0320-00	BFX48/MPS 6518	Si	PNP
TR605	151-0127-02	BSX 20/2N2369	Si	NPN
TR606	151-0127-02	BSX 20/2N2369	Si	NPN
TR607	151-0242-00	2N3904	Si	NPN
TR608	151-0242-00	2N3904	Si	NPN
TR611A) B)	151-1053-00	Matched pair FET Telequipment spec.	Si	N-channel
TR612	151-0127-02	BSX 20/2N2369	Si	NPN
TR613	151-0326-00	BC107	Si	NPN
TR614	151-0320-00	BFX48/MPS 6518	Si	PNP
TR615	151-0320-00	BFX48/MPS 6518	Si	PNP
TR616	151-0320-00	BFX48/MPS 6518	Si	PNP
TR617	151-0320-00	BFX48/MPS 6518	Si	PNP
TR618	151-0127-02	BSX 20/2N2369	Si	NPN
TR619	151-0127-02	BSX 20/2N2369	Si	NPN
TR621	151-0257-00	BF305/2N1990	Si	NPN
TR622	151-0257-00	BF305/2N1990	Si	NPN

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE
TR751A) B)	151-1027-00		Matched pair FET Tektronix spec.	Si N-channel
TR753	151-0320-00		BFX48/MPS 6518	Si PNP
TR754	151-0320-00		BFX48/MPS 6518	Si PNP
TR755	151-0127-02		BSX20/2N2369	Si NPN
TR756	151-0127-02		BSX20/2N2369	Si NPN
TR757	151-0242-00		2N3904	Si NPN
TR758	151-0242-00		2N3904	Si NPN
TR761A) B)	151-1053-00		Matched pair FET Telequipment spec.	Si N-channel
TR762	151-0127-02		BSX20/2N2369	Si NPN
TR763	151-0326-00		BC 107	Si NPN
TR764	151-0320-00		BFX48/MPS 6518	Si PNP
TR765	151-0320-00		BFX48/MPS 6518	Si PNP
TR768	151-0127-02		BSX20/2N2369	Si NPN
TR769	151-0127-02		BSX20/2N2369	Si NPN
TR771	151-0257-00		BF305/2N1990	Si NPN
TR772	151-0257-00		BF305/2N1990	Si NPN
V1	150-0069-00	60 V	NEON 3L Capless	
V301	154-0645-00 154-0646-00 154-0647-00		Type 1474 D (Standard) P31 Type 1458 D P11 Type 1496 D P 7	



TELEQUIPMENT 



MECHANICAL

PART NUMBER	DESCRIPTION	LOCATION *
200-1187-00	Bezel, lighthood	1
390-0220-00	Cabinet side	
161-0084-00	Cable, power with socket, brown-blue-green/ yellow (standard)	
161-0084-01	Cable, power with socket, black-white-green	
343-0212-00	Clamp, handle holding	
131-0651-00	Connector, BNC 50 Ω	2
131-0644-00	Connector, CRT PDA button	CRT
390-0219-00	Cover, baseplate	
390-0186-01	Cover rear	
378-0605-02	Filter	3
348-0169-00	Foot, front	
348-0168-00	Foot, rear	
331-0232-01	Graticule	4
367-0101-02	Handle	
352-0153-00	Holder, fuse	rear panel
136-0455-00	Holder, lamp	5
352-0247-00	Holder, lamp	6
136-0311-00	Holder, lamp	7
366-0214-03	Knob lever, grey	8
366-1310-00	Knob, push button, Grey	9
366-1079-01	Knob, push button, Grey	10
366-1240-00	Knob, red	11
366-1239-00	Knob, grey	12
366-1301-00	Knob, grey	13
366-1266-00	Knob, grey	14
366-1353-00	Knob, grey	15
366-1355-00	Knob, red	16
366-1332-00	Knob, grey	17
366-1241-00	Knob, grey	18
220-0607-00	Nuts	19
333-1453-00	Panel, front	
333-1391-00	Panel, rear label	rear panel
134-0135-00	Plug, power chassis mounting	rear panel
134-0102-00	Plug, supply voltage selector	rear panel
134-0100-00	Plug, trace rotation coil	CRT
337-1465-00	Screen, mumetal CRT	
213-0248-00	Screw 3 mm	11, 12, 13, 14, 16
213-0249-00	Screw 5 mm	15, 17, 18
136-0302-00	Socket	CRT base
136-0457-01	Socket 4 mm	20
136-0317-00	Socket, transistor TO-5	PC106-PC90
136-0343-00	Socket, transistor TO-18	PC106-PC90
136-0344-00	Socket, transistor TO-72	PC106-PC90
136-0315-00	Socket	Volt select
124-0212-00	Tag strip, 3 – way	Rear panel
124-0217-00	Tag strip, 5 – way	Rear panel
129-0191-00	Terminal post, male GND	21
129-0192-00	Terminal post, female GND	22

* Numbers quoted refer to the front panel (opposite).

ASSEMBLIES

ASSEMBLY	PART NUMBER	CIRCUIT REFERENCE
Attenuator	262-0930-00	C901—C909, C911—C919, C921—C923; R901—R909, R911—R919, R921, R922.
Time/div switch	262-0931-00	C101—C108; R101—R109, R111—R118.
P.C.77	670-0876-02	C402, C403, C410, C411; D401, D402, D410, D411; R420.
P.C.90	670-1515-00	C605—C614, C616—C628, C631, C632; D606—D609, D611, D614, D616—D618; R608, R609, R611—R619, R621—R629, R631—R639, R641— R645, R648, R649, R651, R653—R663, R665—R669, R671— R675, R678, R679, R682—R688, R691—R693, R695—R704; TR601, TR603—TR608, TR611—TR619, TR621, TR622; TH601.
P.C.91		C1—C9, C41—C55, C201—C205, C206—C211, C303, C306, C311, C501—C504; D1, D41—D52, D201—D207, D301—D302, D501, D1001— D1004; R1—R4, R6—R9, R11—R19, R21—R25, R26—R29, R31, R41— R85, R87, R89, R202—R233, R303—R304, R308, R311, R316, R451, R453—R456, R501—R507, R1002—R1005; TR1—TR5, TR41—TR48, TR201—TR208, TR501—TR503; S1—S4.
P.C.92	670-1517-00	C401, C406—C408, C412—C417; D405—D409, D412, D413; R402—R407.
P.C.106	670-1519-00	C755—C764, C766—C777, C781, C782; D756—D759, D761—D764, D766; R758, R759, R761—R769, R771—R779, R781—R789, R791— R795, R798, R799, R801, R803—R813, R815—R819, R821— R829, R841—R843, R845—R854; TR751, TR753—TR758, TR761—TR765, TR768, TR769, TR771, TR772; TH751.

CHAPTER 6

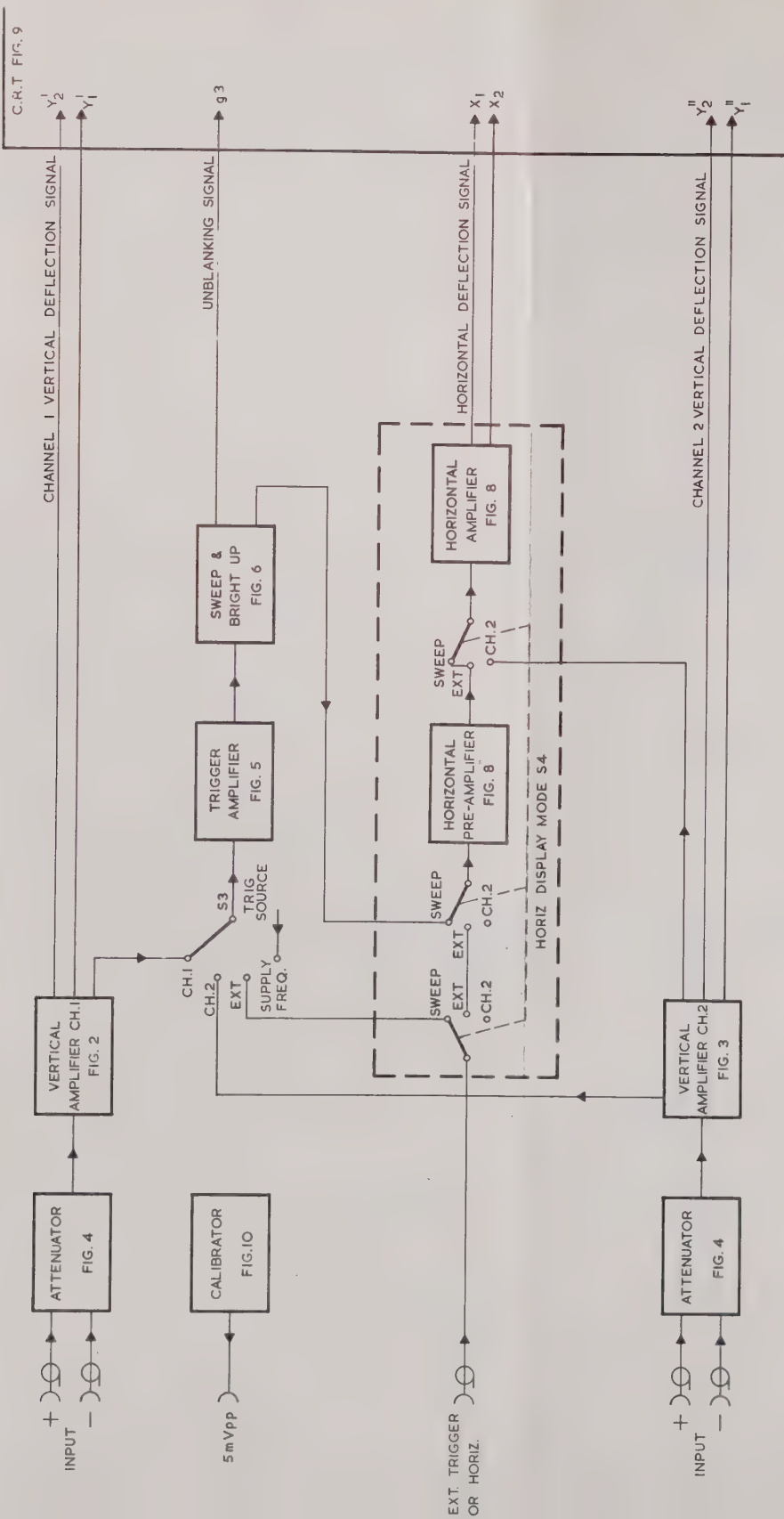
CIRCUIT DIAGRAMS

To minimize the risk of misinterpretation of component values on circuit diagrams, the decimal point has been replaced by the multiplier or sub-multiplier of the basic unit. For instance, 2.2 megohms is shown as 2M2 and 1.8 picofarads is shown as 1p8.

To aid the reader further, in addition to the block Circuit Reference Table in Chapter 5.1, to locate a component in the circuit diagrams, a table is provided at the top of each circuit diagram, in which the circuit reference will appear, where practicable, directly above the component being sought.

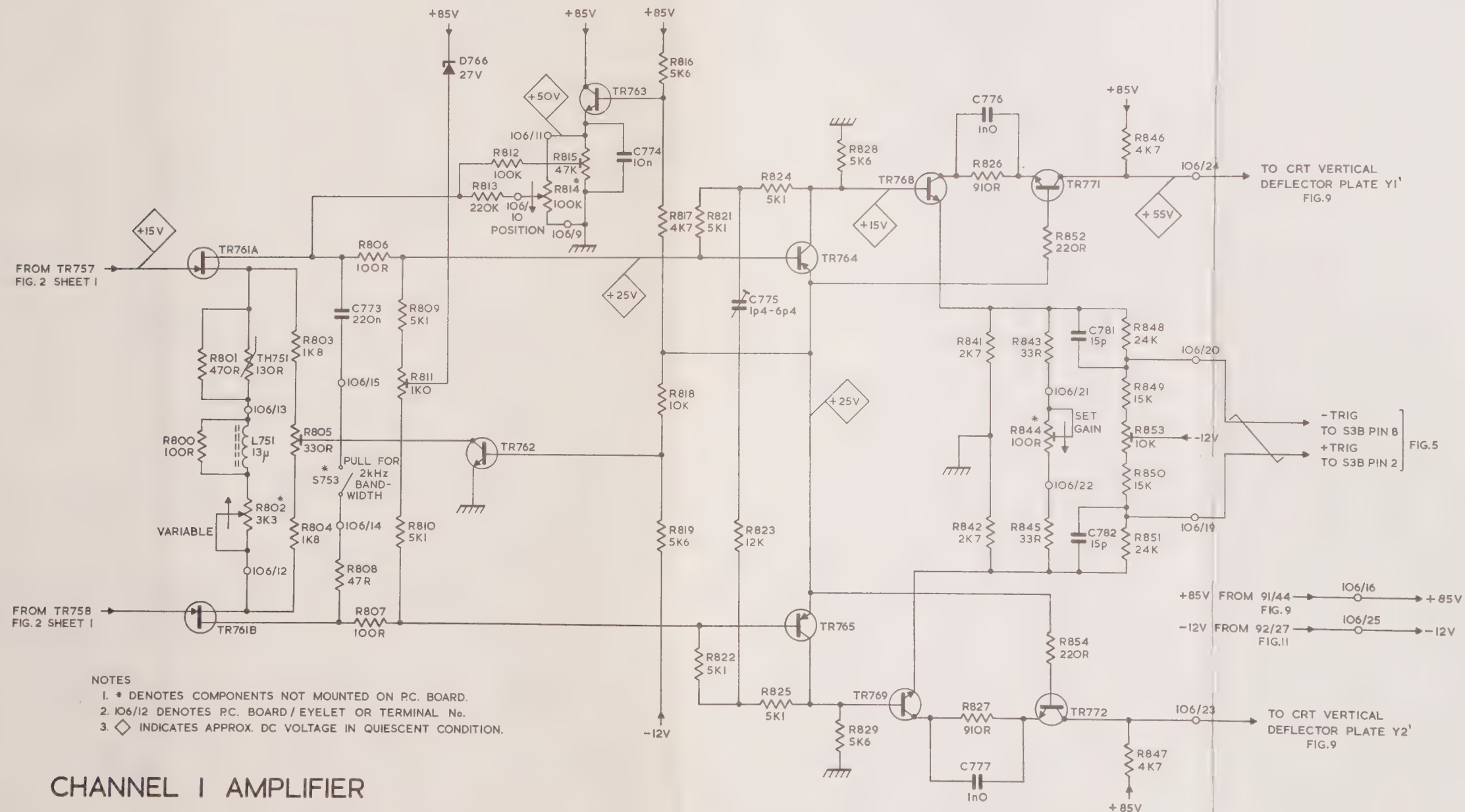
PRINTED CIRCUIT

Blue shows the rear track as seen through the board, Red the component side track and those components referred to in Chapter 4.



BLOCK DIAGRAM
FIG. 1

RESISTORS	801 800	802	803 805 804	808 807	809 811 810	813 812	814	815	816 817 818 819	821 822	823	824 825	828 829	841 842	843 844 845	852 854	846 847	848 849 853 850 851
CAPACITORS				773				774		775				776 777			781 782	
MISC.	TR761	TH751 L751		S753		D776 TR762		TR763				TR764 TR765		TR769 TR768			TR771 TR772	

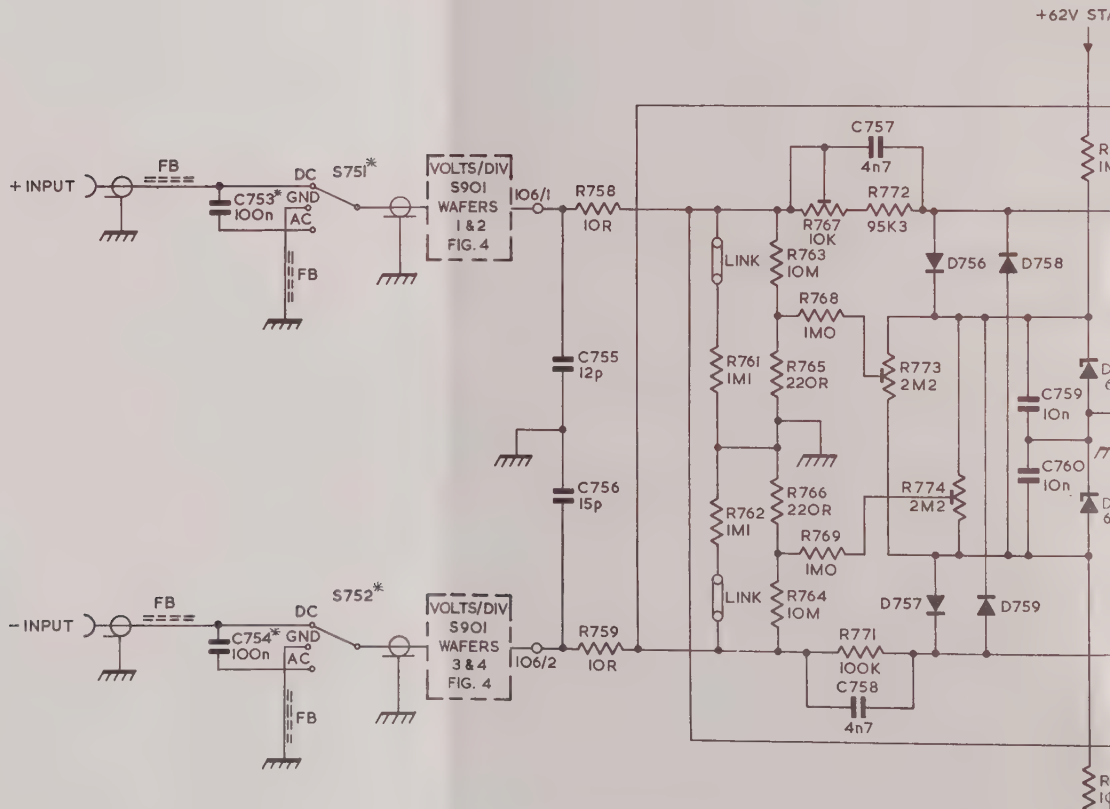


CHANNEL 1 AMPLIFIER
FIG. 2 SHEET 2

ASSEMBLIES

ASSEMBLY	PART NUMBER	CIRCUIT REFERENCE
Attenuator	262-0930-00	C901—C909, C911—C919, C921—C923; R901—R909, R911—R919, R921, R922.
Time/div switch	262-0931-00	C101—C108; R101—R109, R111—R118.
P.C.77	670-0876-02	C402, C403, C410, C411; D401, D402, D410, D411; R420.
P.C.90	670-1515-00	C605—C614, C616—C628, C631, C632; D606—D609, D611, D614, D616—D618; R608, R609, R611—R619, R621—R629, R631—R639, R641— R645, R648, R649, R651, R653—R663, R665—R669, R671— R675, R678, R679, R682—R688, R691—R693, R695—R704; TR601, TR603—TR608, TR611—TR619, TR621, TR622; TH601.
P.C.91		C1—C9, C41—C55, C201—C205, C206—C211, C303, C306, C311, C501—C504; D1, D41—D52, D201—D207, D301—D302, D501, D1001— D1004; R1—R4, R6—R9, R11—R19, R21—R25, R26—R29, R31, R41— R85, R87, R89, R202—R233, R303—R304, R308, R311, R316, R451, R453—R456, R501—R507, R1002—R1005; TR1—TR5, TR41—TR48, TR201—TR208, TR501—TR503; S1—S4.
P.C.92	670-1517-00	C401, C406—C408, C412—C417; D405—D409, D412, D413; R402—R407.
P.C.106	670-1519-00	C755—C764, C766—C777, C781, C782; D756—D759, D761—D764, D766; R758, R759, R761—R769, R771—R779, R781—R789, R791— R795, R798, R799, R801, R803—R813, R815—R819, R821— R829, R841—R843, R845—R854; TR751, TR753—TR758, TR761—TR765, TR768, TR769, TR771, TR772; TH751.

RESISTORS		758 759	761 762	763 765 766 764	767 768 769 771	772 773	774	775 776
CAPACITORS	753 754	755 756				757 758		759 760
MISC.		S751 S752				D756 D757	D758 D759	D761 D762

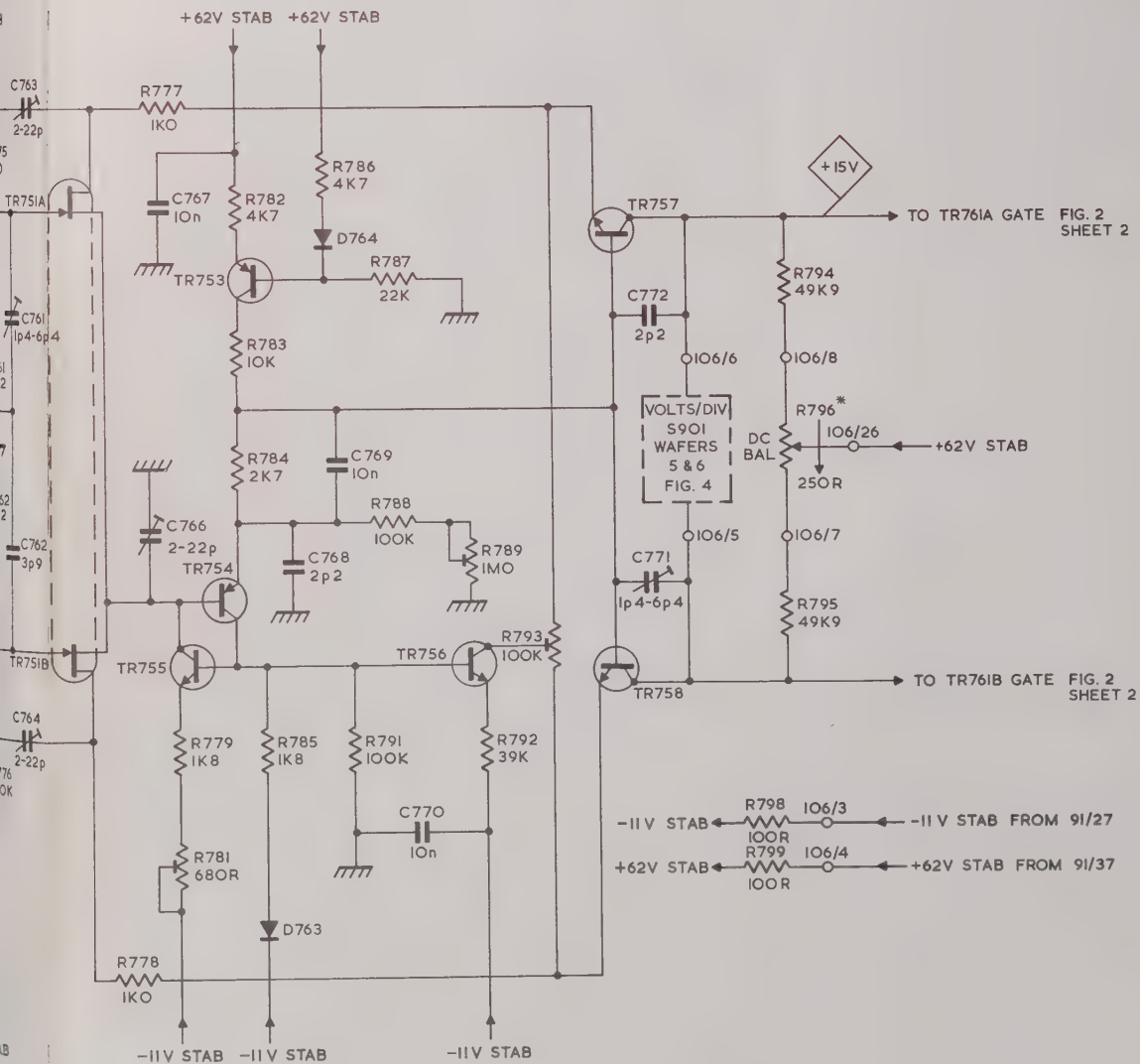


NOTES

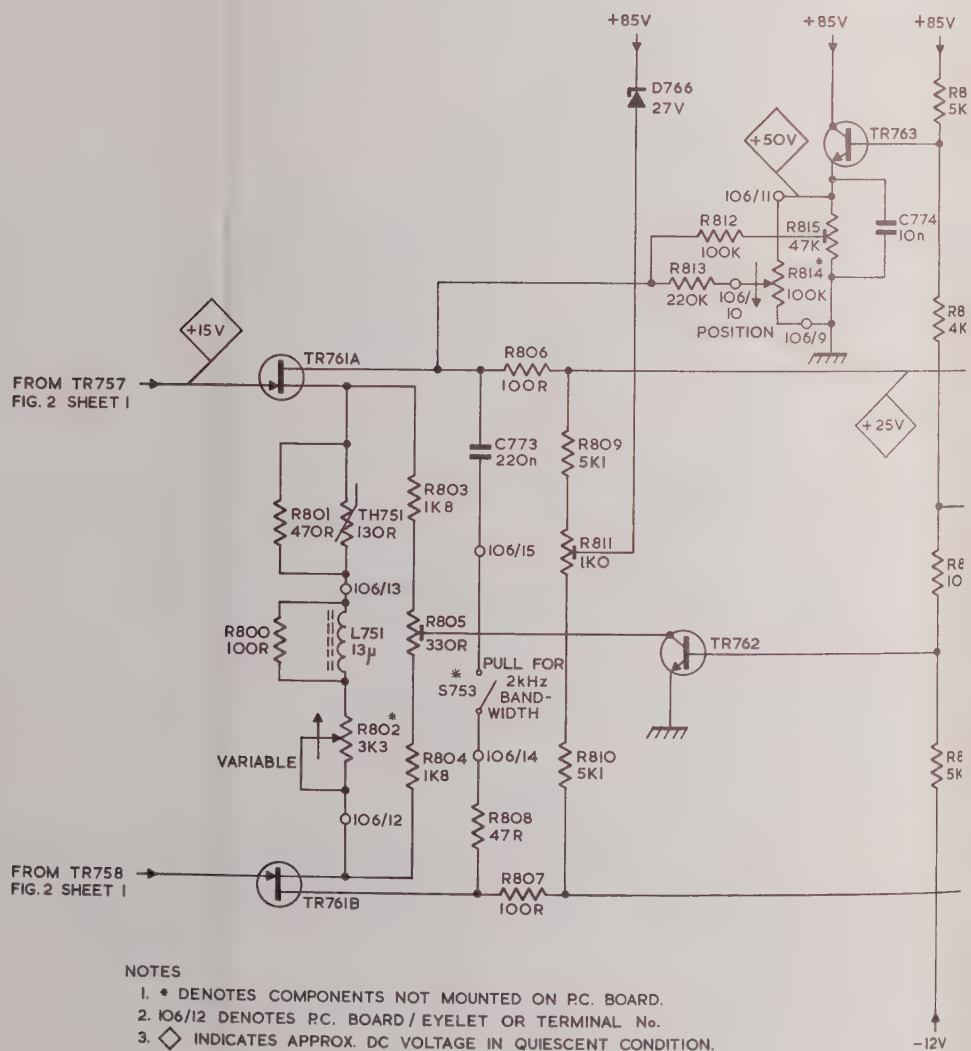
1. * DENOTES COMPONENTS NOT MOUNTED ON P.C. BOARD.
2. 106/2 DENOTES P.C. BOARD / EYELET OR TERMINAL No.
3. ◇ INDICATES APPROX. DC VOLTAGE IN QUIESCENT CONDITION.

CHANNEL 1 AMPLIFIER
FIG. 2 SHEET 1

778	779	782	786	789	793	794
781	783	791	792	796		798
	784	787		799		795
777	785	788				
761	767	768	769	770	772	
762	766			771		
TR751A	TR755	D763	D764	TR756	TR757	
TR751B	TR754	TR753		TR758		



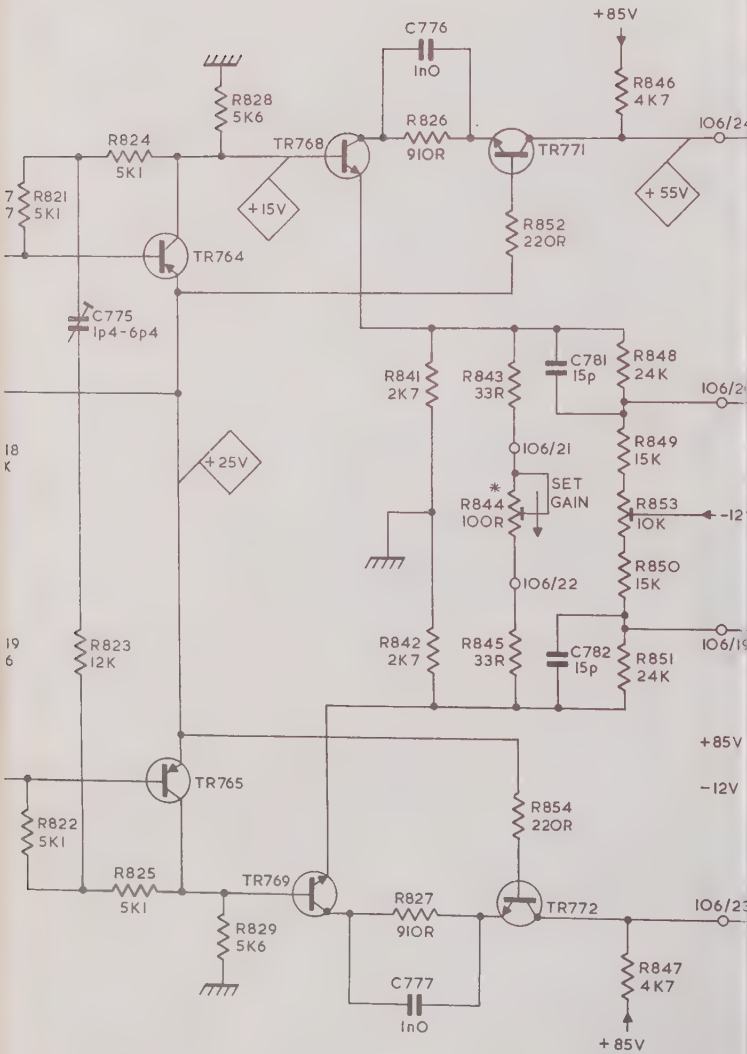
RESISTORS	801 800	802	803 805 804	808	806 807	809 811 810	813 812	814	815	816 817 818 819
CAPACITORS	773					774				
MISC.	TR761	TH751 L751	S753	D776		TR762	TR763			



CHANNEL 1 AMPLIFIER
FIG. 2 SHEET 2

821 822	823 825	828 829	841 842	843 844 845	852 854	846 847	848 849 853 850 851
775			776 777	781 782			
TR764 TR765		TR769 TR768		TR771 TR772			

6
6



18
K

19
6

+85V
-12V



→ TO CRT VERTICAL
DEFLECTOR PLATE Y1'
FIG.9

0



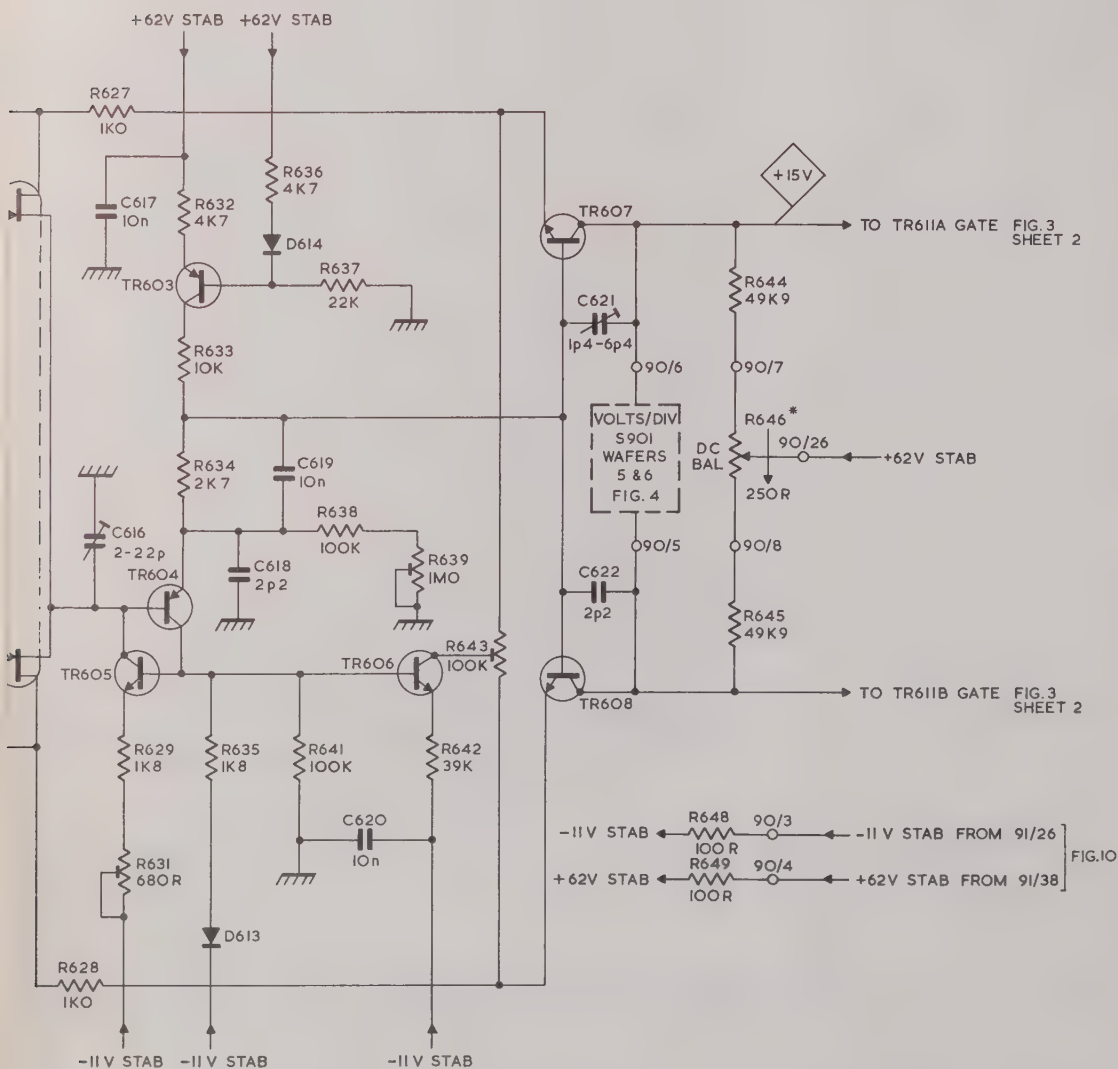
-TRIG
TO S3B PIN 8
+TRIG
TO S3B PIN 2

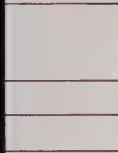
FIG.5

FROM 91/44 → IO6/16 → +85V
FIG.9
FROM 92/27 → IO6/25 → -12V
FIG.11

→ TO CRT VERTICAL
DEFLECTOR PLATE Y2'
FIG.9

628	629	632	636	639	643	644
631	633	641	642	648	646	
	634	637		649	645	
627	635	638				
617	618	619	620	621		
616				622		
601A	TR6O5	D613	D614	TR6O6	TR6O7	
601B	TR6O4	TR6O3		TR6O8		





6
7

90/24 → TO CRT VERTICAL
DEFLECTOR PLATE Y1"
FIG. 9



8

9

03

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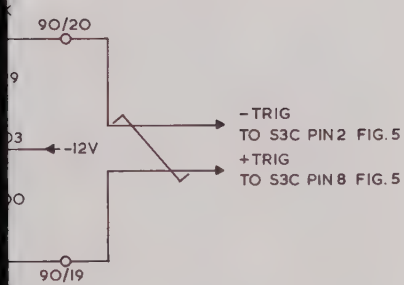
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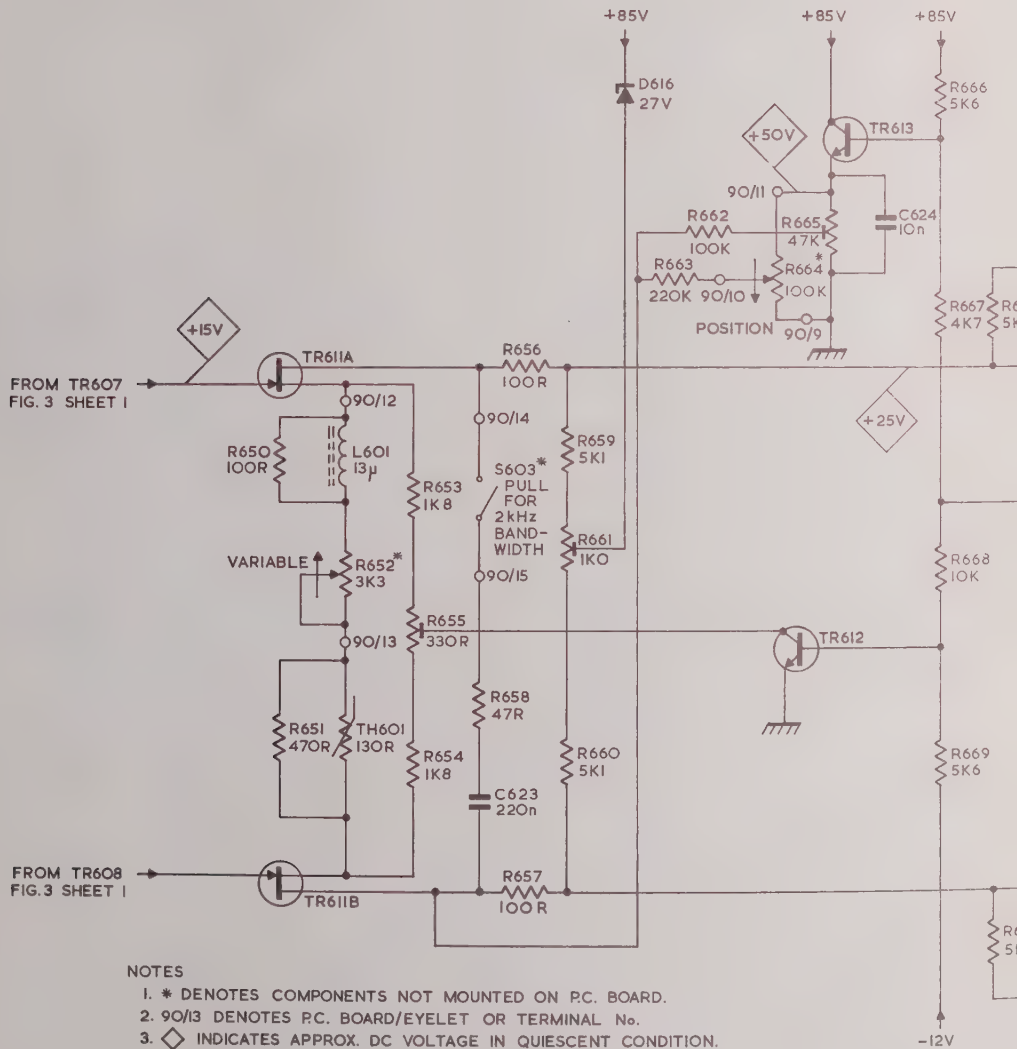
40



90/23 → TO CRT VERTICAL
DEFLECTOR PLATE Y2"
FIG. 9

07
7

RESISTORS	651	652	653	658	656	659	663	664	665	666	671
	650		655 654		657	661 660		662		667 668 669	672
CAPACITORS	623									624	
MISC.	TR611	TH601 L601	S603		D616		TR613		TR612		

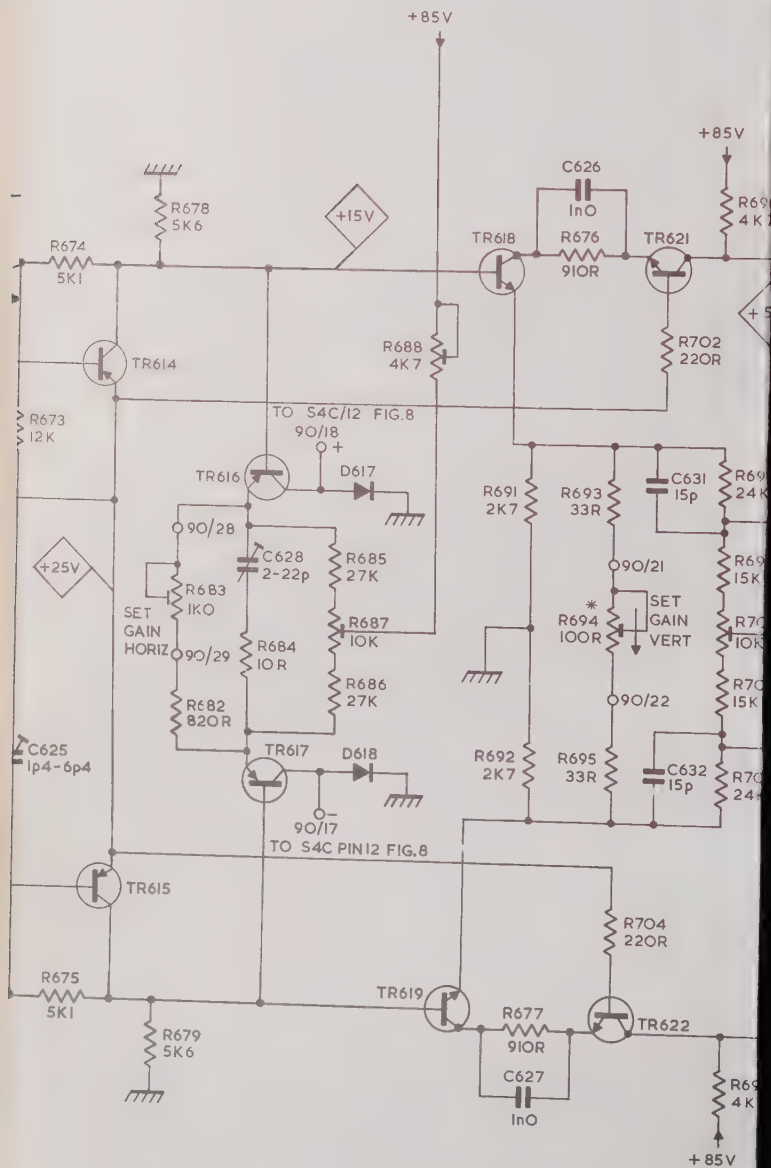


CHANNEL 2 AMPLIFIER

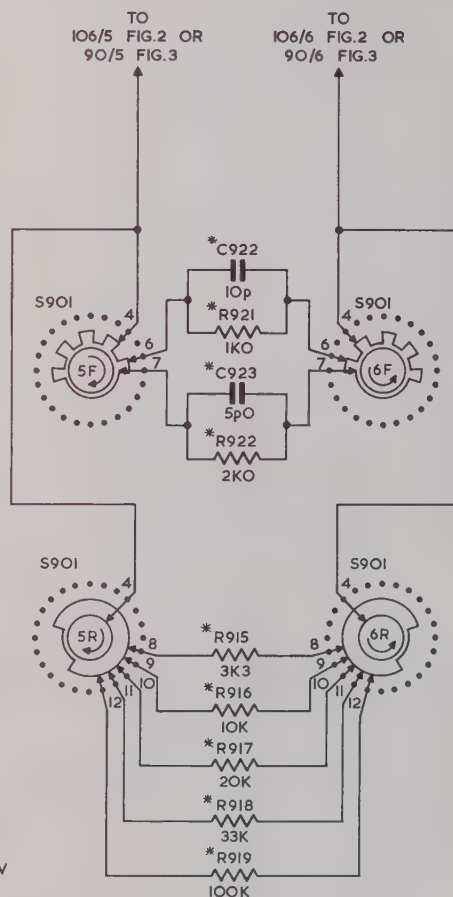
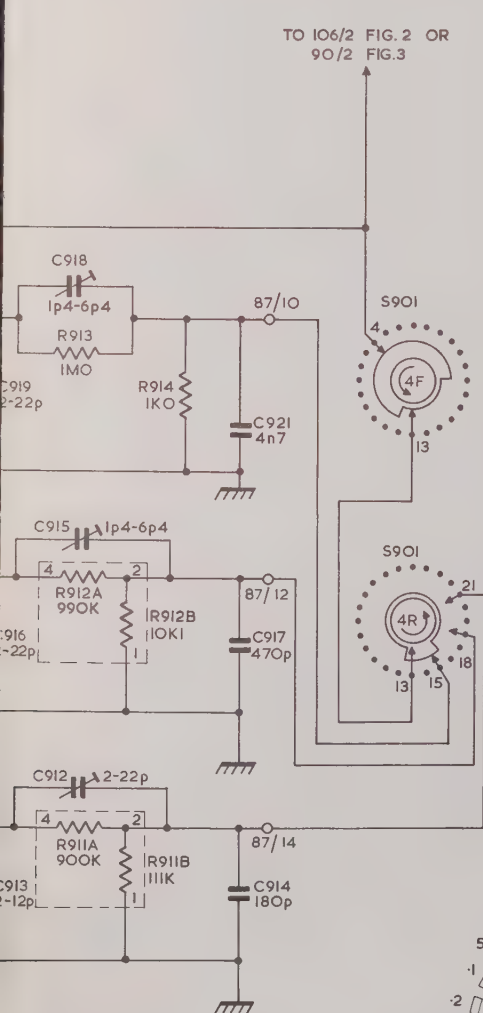
FIG. 3 SHEET 2

73	674 675	678 679	684	685 687 686	691 692	693 694 695 676	702 704	696 697	698 699 703 700 701
25		682 683	628		627	626	631 632		
	TR614 TR615	TR616 TR617	D617 D618	TR618 TR619		TR621 TR622			

6C
6C



913 912A 911A	914	921 922	915 916 917 918 919
918 915 912	921 917 914	922 923	
S901-4F S901-4R		S901-5F S901-5R	S901-6F S901-6R

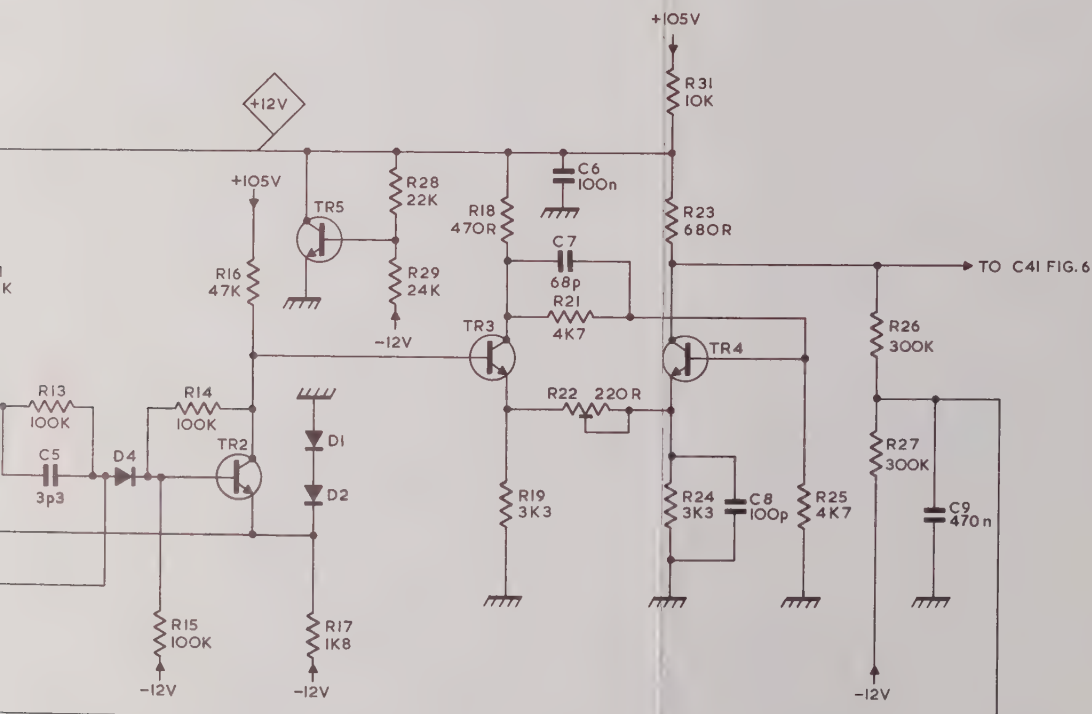


CHANNELS HAVING THE SAME COMPONENT
CHANNELS 1 & 2
NOT MOUNTED ON P.C. BOARD.
D/EYELET OR TERMINAL No.
FULLY ANTICLOCKWISE POSITION,
INDICATE CLOCKWISE DIRECTION



FRONT PANEL MARKING

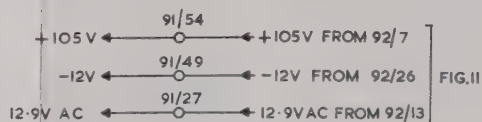
13	15	14	16	17	28	18	21	31	25	26
					29	19	22	23		27
5							6	24	8	9
							7			
D4	TR2	TR5		TR3				TR4		
		D1								
		D2								



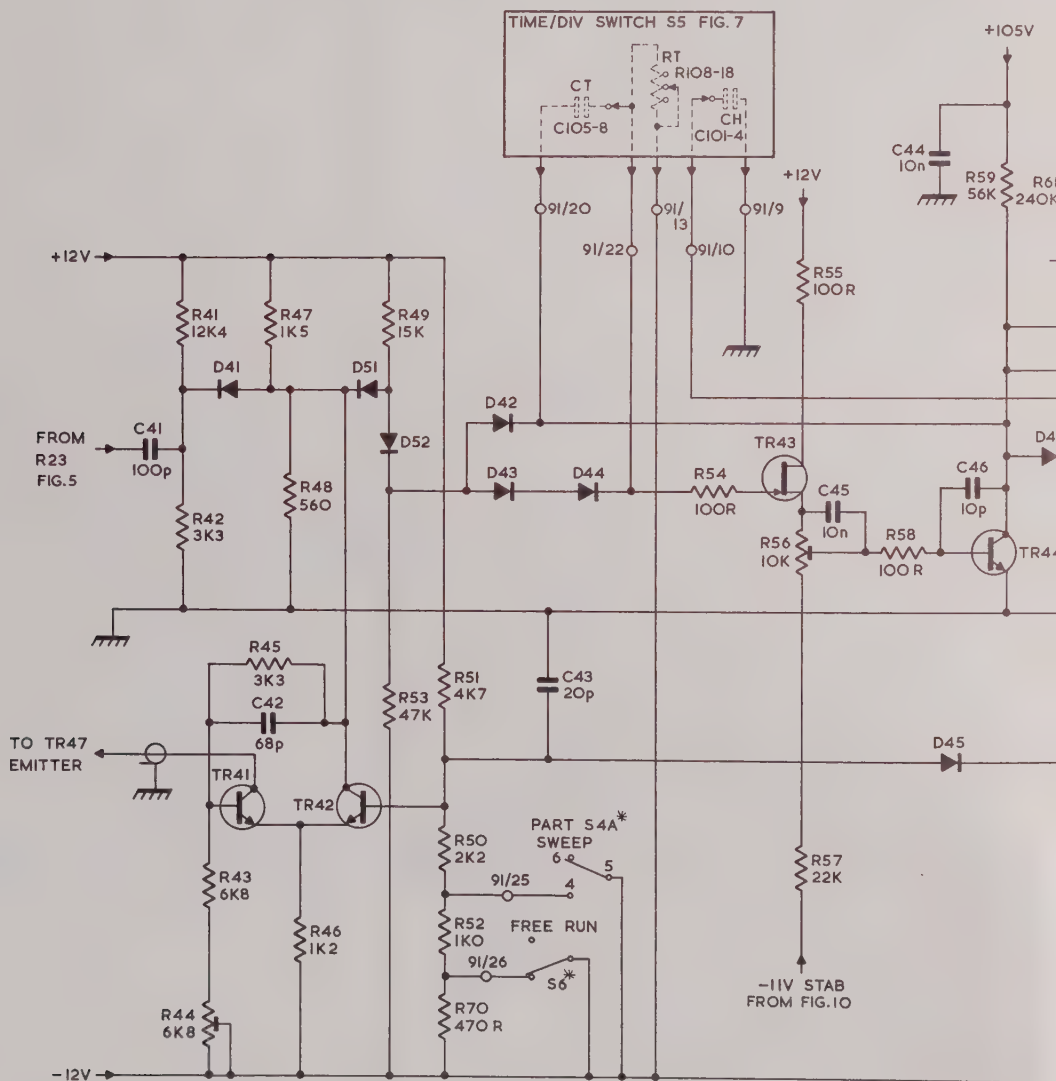
NOTES

- * DENOTES COMPONENTS NOT MOUNTED ON P.C. BOARD.
- 91/2 DENOTES P.C. BOARD/EYELET N^o.
- ◇ INDICATES APPROX. DC VOLTAGE IN QUIESCENT CONDITION.

TRIG COUPLING	
AUTO	○ AC S2A
	○ DC S2B
TRIG SOURCE & SLOPE	
+ ○ -	S3A
○ CH.1	S3B
○ CH.2	S3C
LINE FREQ	○ EXT. S3D
FRONT PANEL MARKING	SWITCH REF.



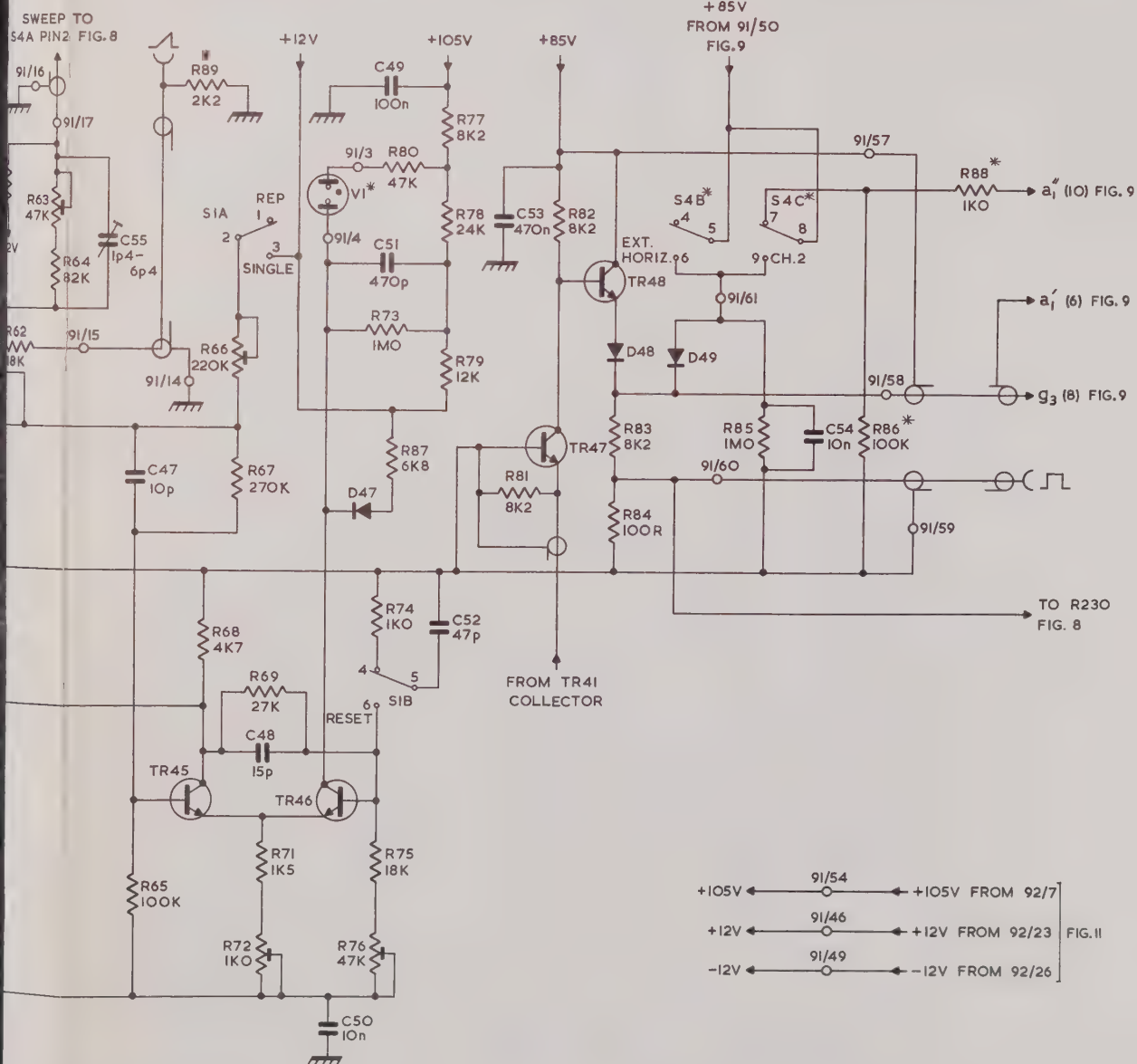
RESISTORS	41 42	47 45	49 53	51 50 52 70	54	55 56 57	58	59
CAPACITORS	41	42			43		45	44 46
MISC.	D41 TR41	D51 D52 TR42	D42 D43	D44 S4		TR43		D45 TR44 D4



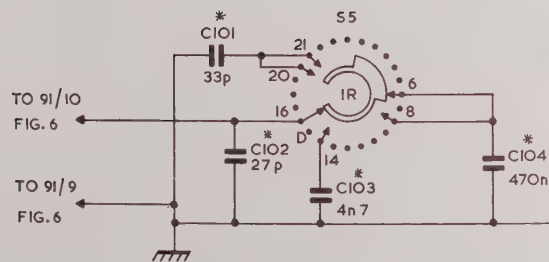
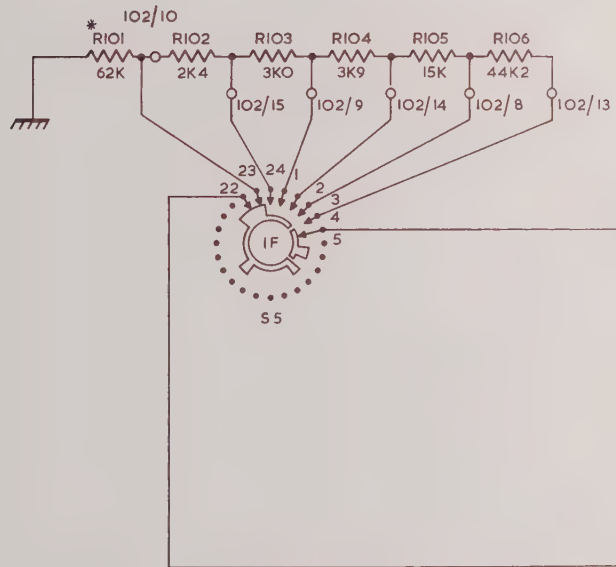
SWEEP & BRIGHT UP
FIG. 6

NOTES:

1. * DENOTES COMPONENTS IN PART S4A*
2. 91/25 DENOTES PC BOARD
3. S4 ALSO APPEARS ON FIG. 7



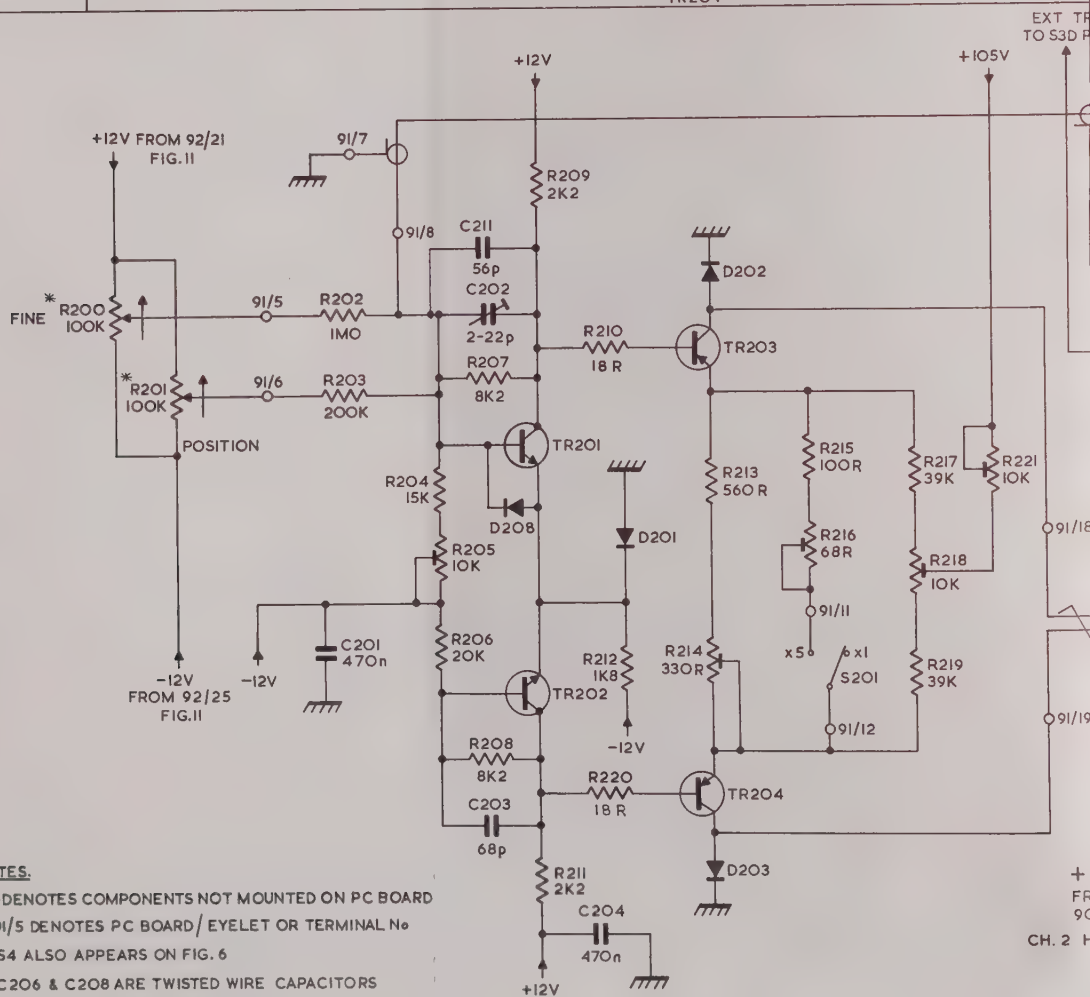
RESISTORS	IO1	IO2	IO3	IO4	IO5	IO6
CAPACITORS	IO1 IO2	IO3	IO4			



TIME / DIV. SWITCH
FIG. 7

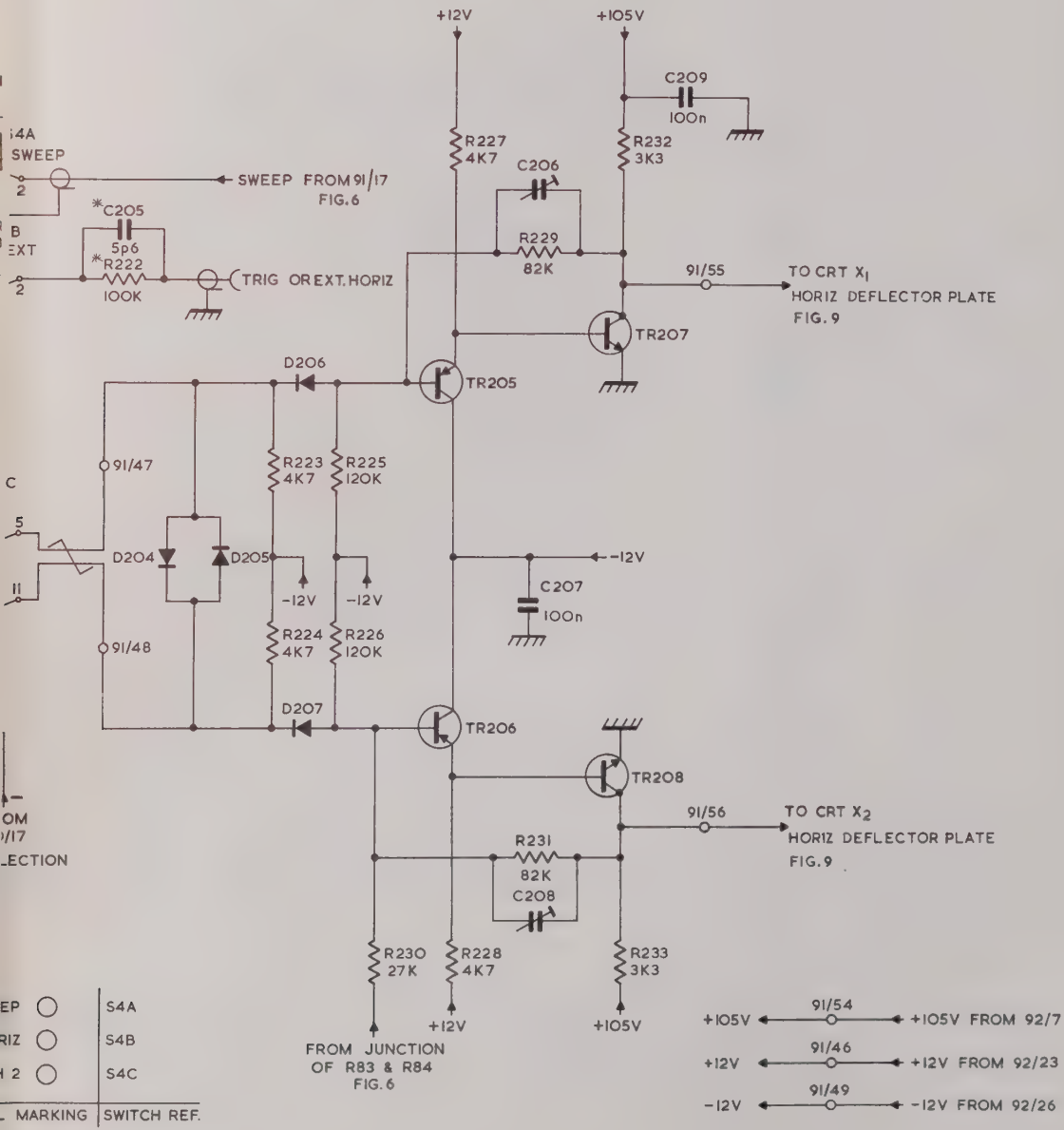
NOTES
1. * DENOTES COMP
2. IO2/4 DENOTES P

RESISTORS	200	201	202 203	204 205 206	207 208	209 211	210 212 220	213 214	215 216	217 218 219	221
CAPACITORS			201			211 202 203	C204				
MISC.						D208 TR201 TR202	D201	D202 D203 TR203 TR204	S201		

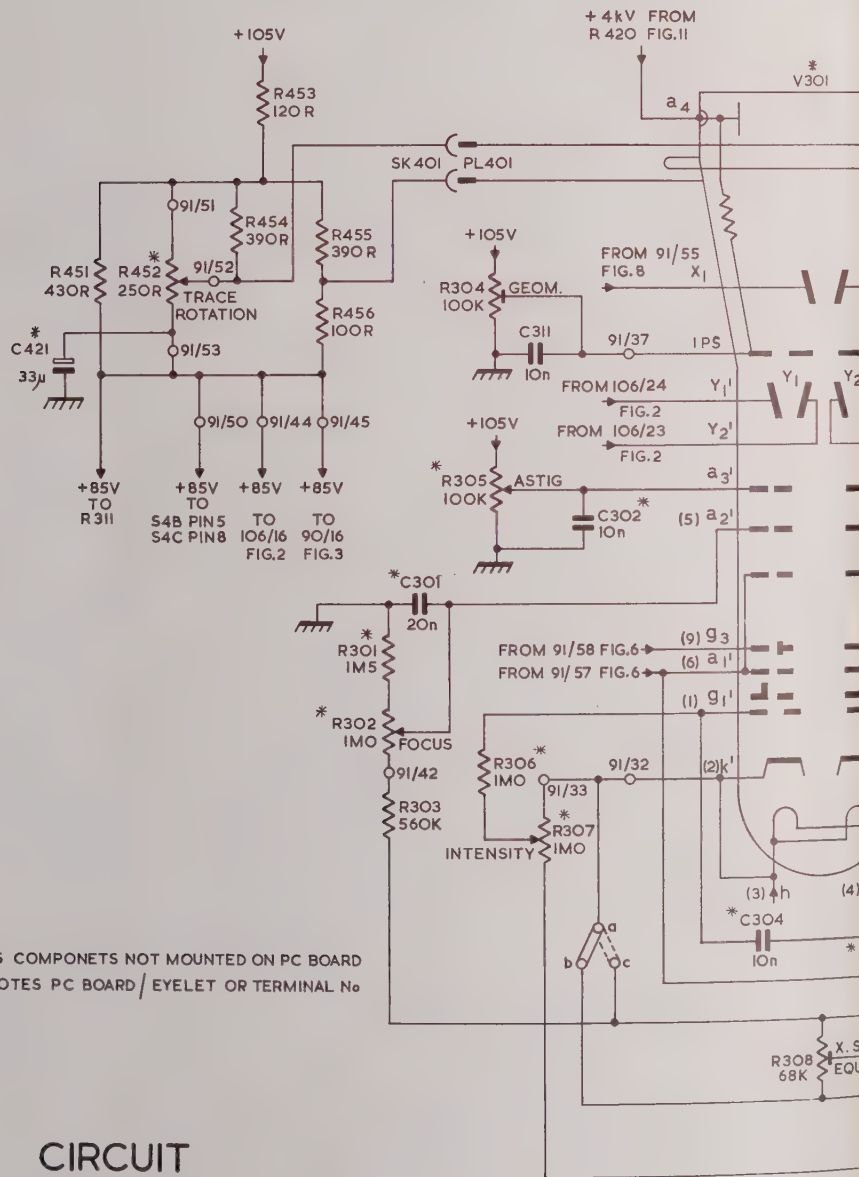


HORIZONTAL AMPLIFIER
FIG. 8

222	223	225	230	227	229	232
	224	226		228	231	233
205					206	209
					207	
					208	
D204	D205	D206		TR205		TR207
		D207		TR206		TR208



RESISTORS	451	452	454	455	301	304	307	308
			453	456	302	305		
					303	306		
CAPACITORS	421				301	311	302	304
MISC.					SK401	PL401		V301

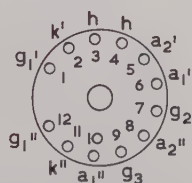
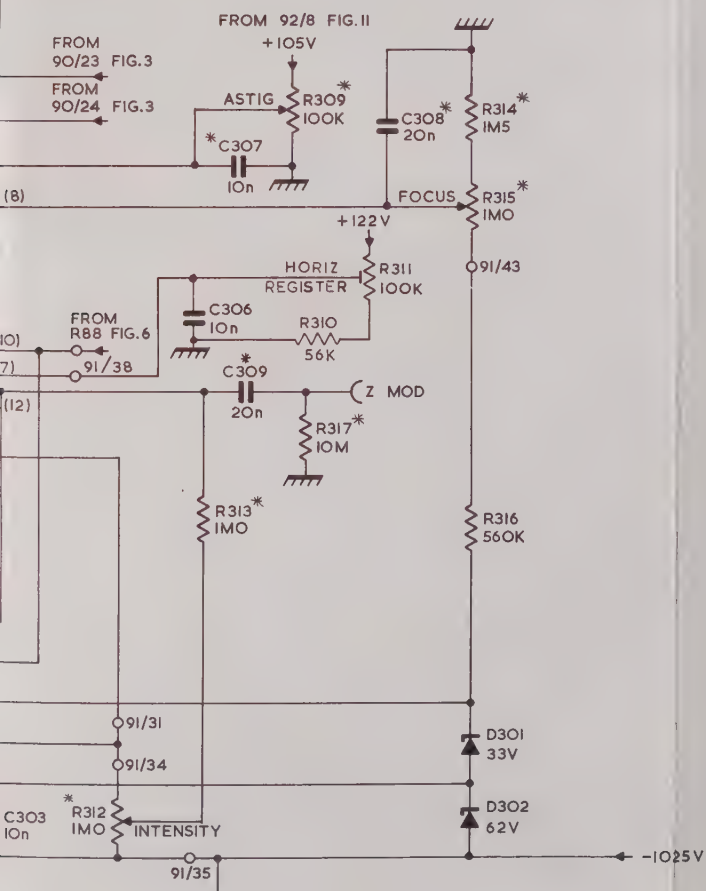
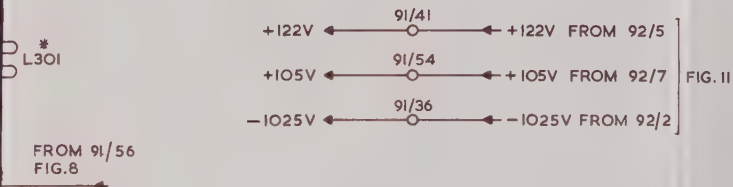


NOTES

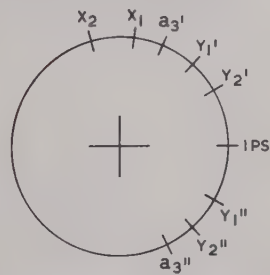
- * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD
- 91/50 DENOTES PC BOARD / EYELET OR TERMINAL No

C.R.T. CIRCUIT
FIG. 9

312	313	309	314
		311 310	315
		317	316
306	307	308	
	309		
L 301			D 301
			D 302

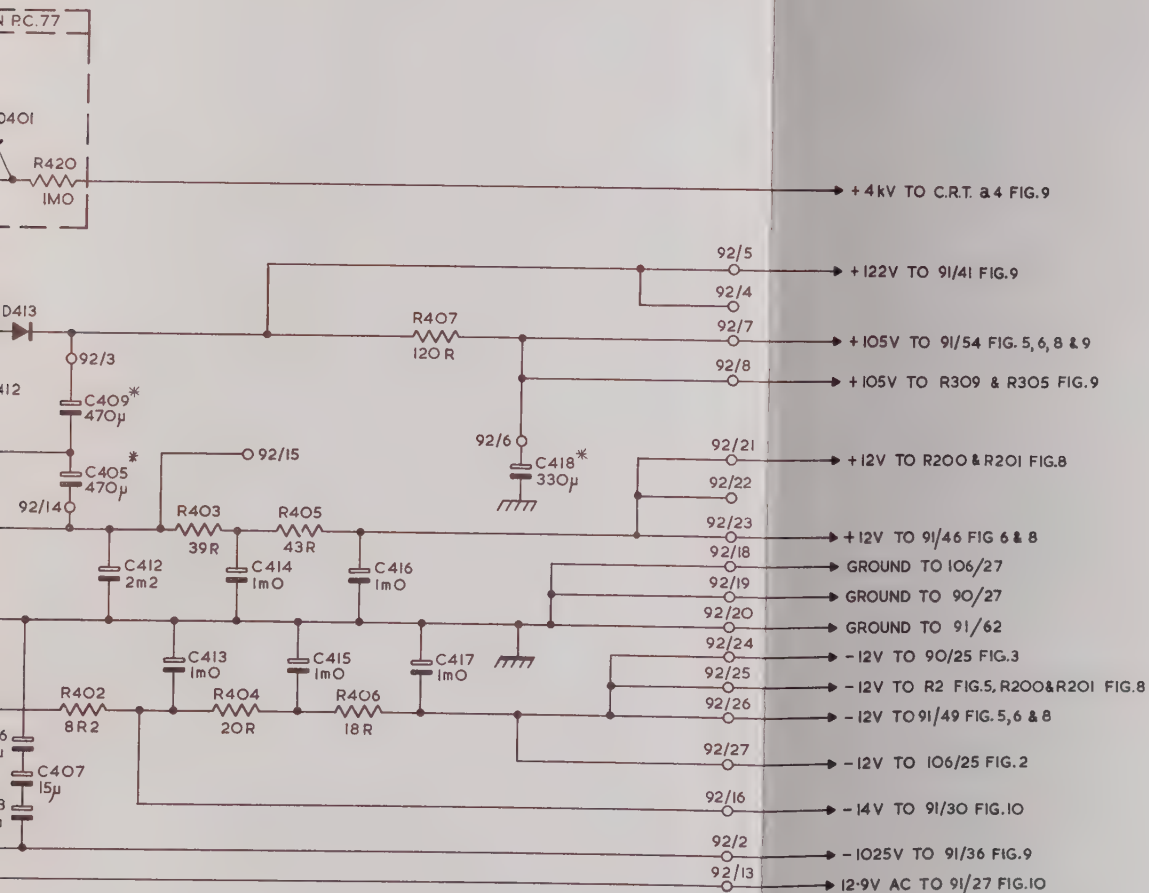


TUBE BASE FROM REAR



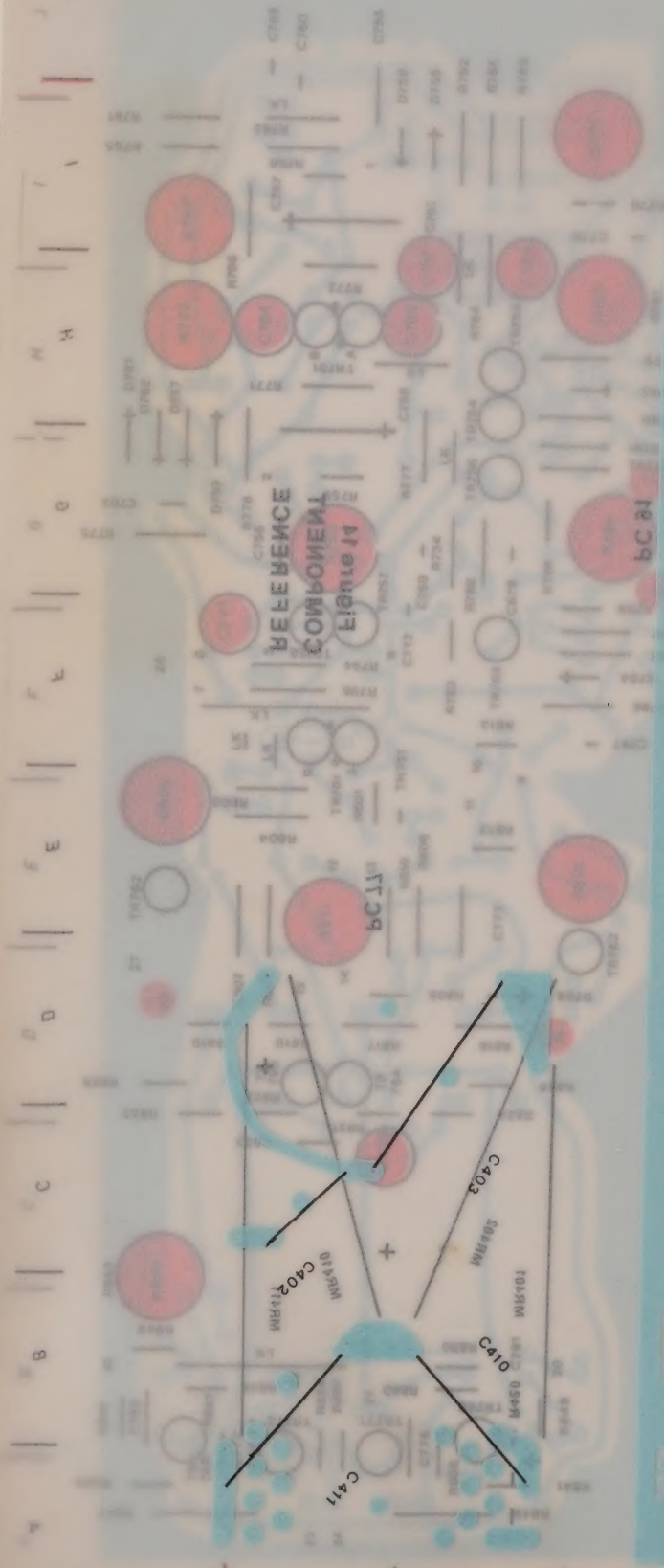
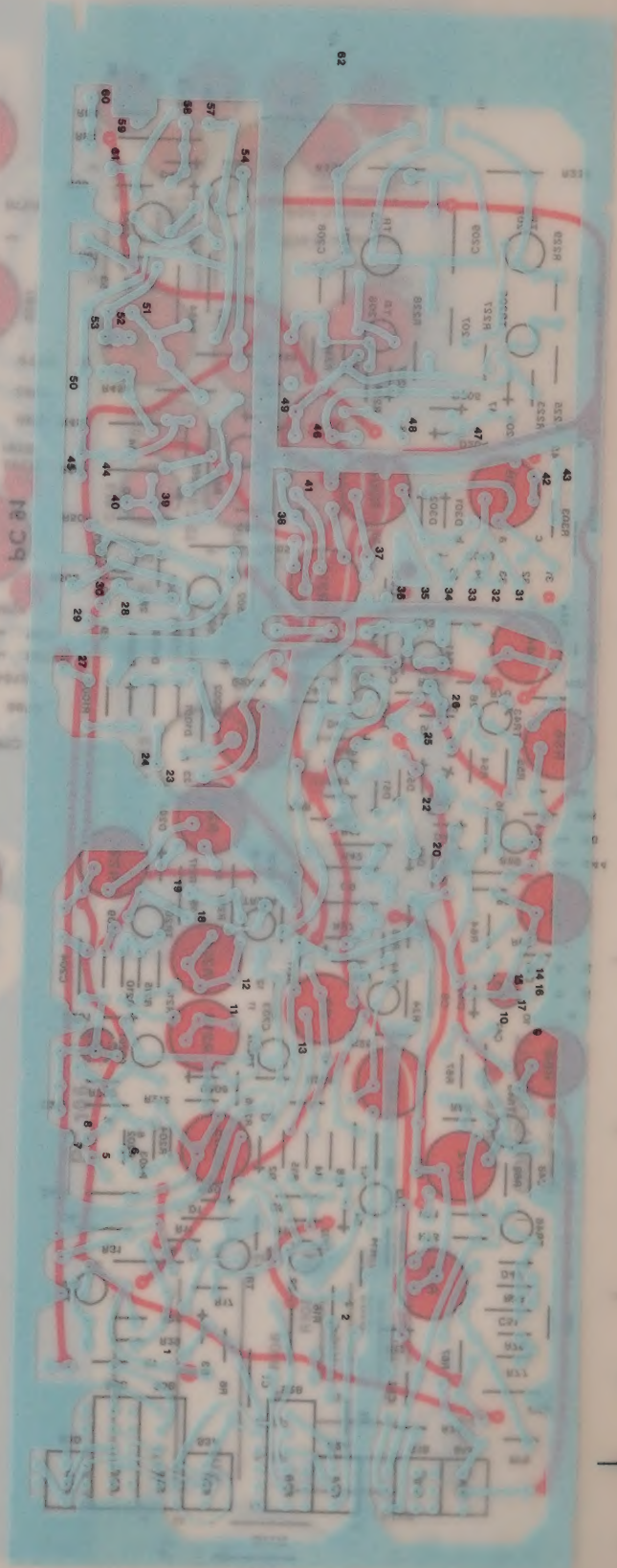
SIDE PIN CONNECTIONS FROM REAR

420	402	403	404	405	406	407	
406	409	412	413	414	415	416	417
407	405						418
408							
D413							



NOTES

1. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD
2. 92/5 DENOTES PC BOARD / EYELET OR TERMINAL No



TELEQUIPMENT



MP MASTER



MA24048